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Assessment of Water and Sanitation Services in the White Nile State, Sudan

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Abstract

The present rate of expansion in water and sanitation services in the White Nile State does not keep pace with population and animal growth rates. The people; women and children are suffering from the scarcity of water and the low coverage of sanitation facilities.

This study aim at making good assessment to the situation of water and sanitation services and try to put strategic recommendations for improving drinking water and sanitation services in the White Nile State, in Sudan, to satisfy the human and animal needs and to consider the natural, administrative and financial conditions of the State following the national and international directories.

The study considers the general situation of water and sanitation services world wide, Sudan and in particular the White Nile Sate, taking the four provinces of the State and their localities. By using available data for the year 1999 such as; population, animal wealth, water demand and sanitation facilities, and by calculating and analyzing these data, the expected demand of water and sanitation facilities for the years 2005, 2010 and 2015 were determined, results were presented in tables and figures. Many points were discussed and based on this discussion; the study ends up with very detailed conclusions and significant recommendations which mainly focused on; the integration between water and sanitation services, building good information system for water and sanitation data, improving the quality and the quantity of water considering the time frames and the budgets and try to improve the administrative sectors and build the services management and the health sectors capacities.

الملخص

إن معدلات التوسع الحالية لخدمات المياه و إصحاح البيئة في ولاية النيل الأبيض لا ترقى إلى مستوى معدلات النمو السكاني و الحيواني ، الحقيقة التي باتت تؤرق النساء و الأطفال في الولاية و جعلتهم يعانون من ندرة المياه، ومن التغطية الضئيلة و غير الكافية لخدمات إصحاح البيئة.

تهدف هذه الدراسة إلى خلق تقييم جيد للوضع الحالي للمياه والخدمات الصحية، ومحاولة وضع توصيات استراتيجية لتحسين مياه الشرب و الخدمات الصحية في ولاية النيل الأبيض ، في السودان ، وهذا، لمواجهة احتياجات الإنسان و الحيوان وللأخذ بعين الاعتبار الأوضاع الطبيعية، والإدارية، والمالية للولاية، تبعا للموجهات القومية والدولية.

كما تهتم هذه الدراسة بالوضع العام للمياه و إصحاح البيئة في العالم، و السودان، ثم بالتحديد ولاية النيل الأبيض ، آخذة في الاعتبار محافظات الولاية الأربعة بمحلياتها. وباستخدام المعلومات و الإحصائيات المتوفرة للعام 99 مثل : السكان ، و الثروة الحيوانية ، و احتياجات المياه و مرافق إصحاح البيئة ، تم حساب و تحليل هذه المعلومات و بالتالي تم تقدير الاحتياجات المتوقعة للمياه وإصحاح البيئة للأعوام 2005، 2010، و2015.

عرضت النتائج في جداول و مخططات و من ثم، نوقشت عدة نقاط ، و اعتمادا على هذا النقاش؛ انتهت الدراسة إلى ملخص مفصل، و توصيات مهمة ركزت أساسا على؛ التداخل بين الخدمات الصحية و المياه ؛ بناء نظام معلوماتي جيد للمياه و إصحاح البيئة ؛ و تحسين كمية و نوعية المياه آخذين بعين الاعتبار الجداول الزمنية و الميزانيات، وكذلك محاولة تحسين القطاع الإداري، وبناء قدرات العاملين بإدارة الخدمات والقطاع الصحي.

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Chapter 1

Introduction

1.1 General

Clean water is a basic essential for life. However, over one billion people worldwide lack access to safe drinking water, and almost half the world's population lack adequate sanitation. This situation affects their health, environment, basic dignity and children's future. For some countries the problem is scarcity of water, while in others water is plentiful but of poor quality.

Around 80% of all sickness and disease in the world is caused by inadequate water or sanitation, according to the WHO. Water-related diseases cause 2.2 million deaths each year, mostly among children under the age of five [7].

Inadequate water, sanitation and hygiene not only cause sickness and death, but also increase health costs, reduce people's ability to earn a living, and reduce school enrolment rates, especially for girls. Shortages in water can lead to harvest failure, and even famine. All these factors contribute to

the continuing cycle of poverty in developing countries.

The poorest and most vulnerable people are worst affected by this problem. In most societies, women and children bear the responsibility for fetching water for the family a time-consuming, and physically demanding duty. Women in Africa and Asia, on average, have to walk 6 km a day just to get water.

1.2 Background and Motivation

The continent in transition, Africa is facing a largely forgotten, endemic water and sanitation crisis that debilitates and kills in large numbers, limiting economic growth, educational access, and life opportunities. Although sector development cannot keep up with population growth and coverage is declining, reforms have been initiated in many countries to reverse this situation. These reforms seek to create financially sustainable service provision, decentralize decision-making, increase efficiency through engaging in the private sector, and encourage transparency by increased civil society consultation and participation.

The following tables show the people without water supply and without proper sanitation world wide:

Table (1.1): People without clean water supply (millions)

Africa	300
Asia	693
Latin America & Caribbean	78
Global	1099

Table (1.2): People without proper sanitation services (millions)

Africa	313
Asia	1916
Latin America & Caribbean	117
Global	2403

* ***Source: Global Water supply and Sanitation Assessment report 2000.***

Sudan is the largest country in Africa; with an area of 2.5 million square km. This large area covers a diverse range of agro-ecological zones. The northern part of the country has large land areas that are arid or semi-arid, 51% of the country lies in the semi-arid zone. These areas have limited supplies of renewable water resources and limited potential for rain-fed agriculture.

Sudan is an area well known for its aridity with desertification having affected nearly 60% of the territory. It is estimated that only 10% of potential arable land is cultivated and less than 1% is irrigated. The provision of water in Sudan continues to be a critical problem in both rural and urban areas, especially in the summer months.

Considering the distribution of water resources in Sudan areas less than 200 mm of rainfall depends on rivers and ground water aquifers i.e. North Khartoum, North Kordofan, North Darfur and North Kassala states. The rest of the country enjoys moderate rainfall and proximity to surface water resources (rivers and seasonal streams) in addition to fairly rich aquifers (figure 1.1).

With regard to excreta disposal only 26% of population have access to sanitation, UNICEF has a role in the field through Water Supply and Environmental Sanitation (WES) Project, but its effort have been limited to

certain areas and certain households in these areas.

There are no data regarding the solid waste generation (quality and quantity), storage, collection, transportation and final disposal, but the open dumping and incineration is the main methods of final disposal which may create many hazards. In addition, no any attempts were made to organize source reduction and recycling programs. The localities are responsible for such activity through the public health officers. The main problems are: lack of researches, lack of training, lack of resources such as vehicles and fuel, in addition to the absence of community participation [3].

The following tables show the percentage of people in Sudan with access to safe or improved water and sanitation for year 2000:

Table (1.3): People with Access to Safe or Improved Water (%), 2000

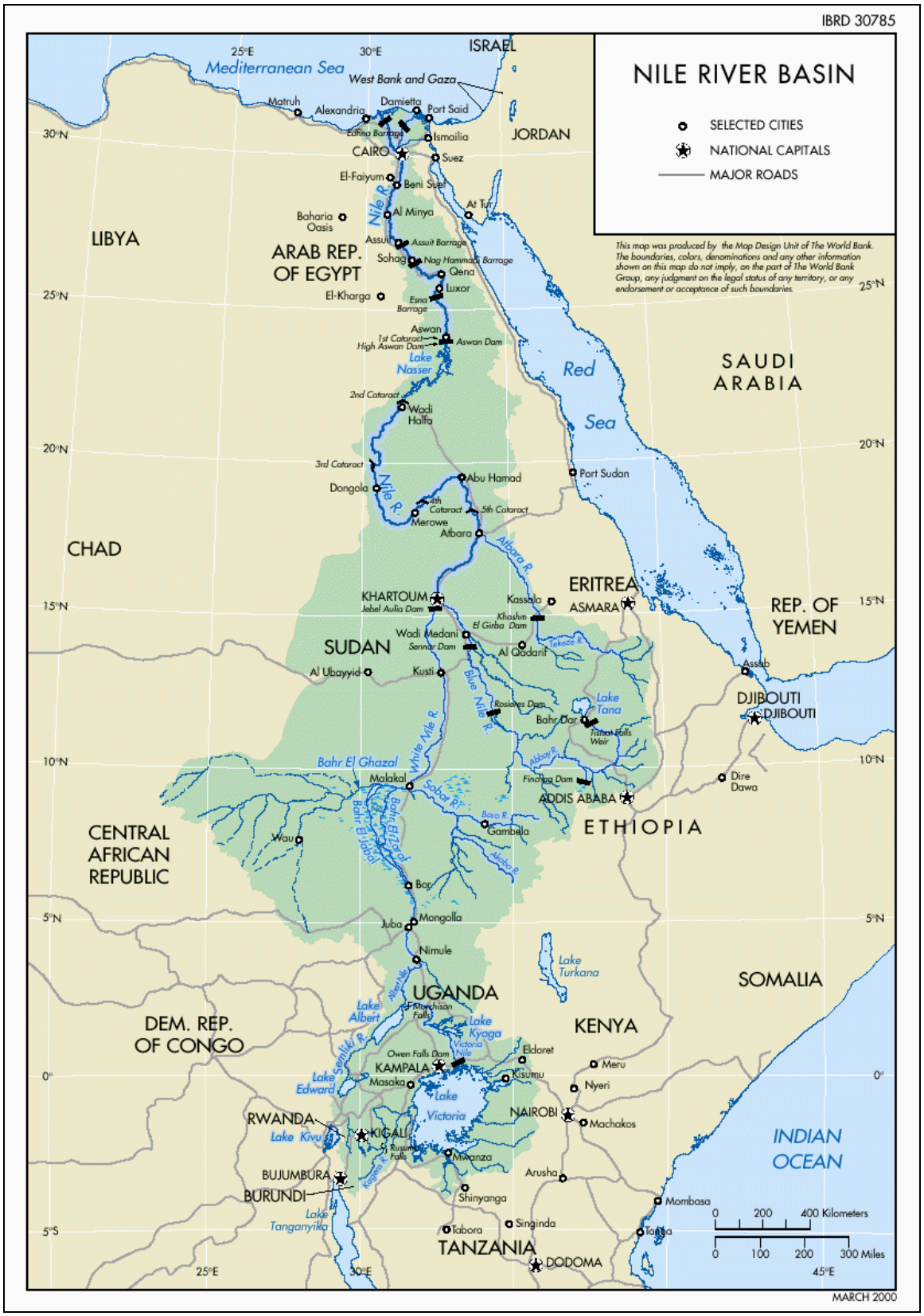
State	*Population (000)*	*People with access to safe/improved water (%)*	Remarks
N. Darfur	1326	55.4	-
S. Darfur	2344	49.6	Daily supply 11.8% of the need
W. Darfur	1653	29.0	12.4 l/c/d
N.Kordofan	1246	79.2	-
S. Kordofan	1089	67.1	Has 5 water basins
W.Kordofan	1537	42.1	Rainfall is the main source
River Nile	872	58.2	Source are wells, Hafirs , Nile, river Atbara
Red Sea	671	N.A	70% of water from open wells
Gezira	3330	77.9	Main source B. Nile & groundwater
Gedarf	1334	59.1	Main source Rehad & Atbara river
White Nile	1439	10.0	White Nile is the major source
Blue Nile	599	23.7	Daily output 16.8% of the need
Kassala	1435	59.6	Mainly wells and river gash
Northern	510	70.9	Mainly wells and river gash

Sinnar	1114	73.9	Blue Nile and ground water
Khartoum	5352	92.9	Mainly the Niles

Table (1.4): People with Access to Improved Sanitation, 2000.

State	% of people
N. Darfour	62.6
S. Darfour	63.1
W. Darfour	48.2
N. Kordofan	51.4
S. Kordofan	73.1
W. Kordofan	36.2
River Nile	83.6
Red Sea	N.A
Geziera	58.1
Gedarif	39.8
White Nile	90.0
Blue Nile	62.7
Kassala	47.1
Northern	78.6
Sinnar	54.5
Khartoum	87.0

* See the Appendix for more information


IBRD 30785
NILE RIVER BASIN
SELECTED CITIES
NATIONAL CAPITALS
MAJOR ROADS
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Mediterranean Sea
ISRAEL
West Bank and Gaza
JORDAN
LIBYA
ARAB REP. OF EGYPT
SAUDI ARABIA
Red Sea
CHAD
SUDAN
ERITREA
ASMARA
REP. OF YEMEN
DJIBOUTI
ETHIOPIA
CENTRAL AFRICAN REPUBLIC
DEM. REP. OF CONGO
UGANDA
KENYA
SOMALIA
RWANDA
BURUNDI
TANZANIA
INDIAN OCEAN
Matruh
Alexandria
Damietta
Port Said
Edfina Barrage
Ismailia
CAIRO
Suez
El-Faiyum
Beni Suef
Nile R.
Al Minya
At Tur
Baharia Oasis
Assuit
Assuit Barrage
Sohag
Nag Hammadi Barrage
Qena
Luxor
El-Kharga
Esna Barrage
Aswan
1st Cataract
High Aswan Dam
Aswan Dam
Lake Nasser
2nd Cataract
Wadi Halfa
3rd Cataract
Dongola
Abu Hamad
Port Sudan
4th Cataract
5th Cataract
Merowe
Atbara
Atbara R.
KHARTOUM
Jebel Aulia Dam
Kassala
Khashm El Girba Dam
Wadi Medani
Sennar Dam
Al Qadarif
Tekeze R.
Asmara
Assab
Al Ubayyid
Kusti
Blue Nile R.
Roseires Dam
Lake Tana
Bahr Dar
Tisisat Falls
Weir
DJIBOUTI
Bahr El Ghazal
White Nile R.
Abbay R.
Finchaa Dam
Dire Dawa
Malakal
Sobat R.
ADDIS ABABA
Baro R.
Gambela
Wau
Bahr El Jebel
Bahr El Ghazal
Aweil
Akobo R.
Bor
Mongolla
Juba
Nimule
Lake Turkana
Albert Nile
Lake Albert
Murchison Falls
Lake Kyoga
Victoria Nile
Owen Falls Dam
Eldoret
KAMPALA
Meru
Kisumu
Nyeri
Semliki R.
Lake Edward
Masaka
Lake Victoria
NAIROBI
Machakos
KIGALI
Lake Kivu
Rusumo Falls
Mwanza
Arusha
BUJUMBURA
Kagera R.
Shinyanga
Mombasa
Lake Tanganyika
Tabora
Singinda
Tanga
DODOMA
0 200 400 Kilometers
0 100 200 300 Miles
MARCH 2000
25°E
30°E
45°E
30°N
25°N
20°N
15°N
10°N
5°N
0°
5°S

Figure (1.1): The Nile River Basin Map [11]

1.3 Objectives

The study was made according to the following objectives:

1. To asses the water and sanitation services situation in the urban, semi-urban and rural areas of the State.
2. To asses the available water resources.
3. To asses and determine future needs of water and sanitation services (duration 1999-2015).
4. To asses the administrative and financial systems in water and sanitation department of the state.
5. To put strategic recommendations to cover the needs of water and sanitation in each province of the state.

1.4 Scope of work

The study will introduce a general background about water and sanitation situation globally and then in Sudan particularly taking the White Nile State as a study area, to asses the water and sanitation services in the state according to the data available (for the year 1999) for population, animal wealth, water consumptions and available sanitation services in the White Nile state, with its localities in each province (Kosti, Edduweim, Gitaina and Jabalain) either in urban, semi-urban or rural areas. The water department of the state together with UNICEF and other water authorities like the National Water Corporation (NWC), the Environmental Health Department, the Humanitarian Aid Commission of the state (HAC), Plan Sudan organization, Kennana Sugar Factory…..etc, provided most of the data needed for this

study and of course there was field visits to a number of localities and villages of the White Nile State to help in collecting data and water samples direct from the field. Also with the help of some old socio-economical and environmental studies.

Chapter 2

Literature Review

2.1 Water & Environmental Sanitation in Sudan [10]

Only 35 % of the population has access to safe drinking water. According to WHO, about 90 % of major epidemics in the country are water – borne or water related and some 40 % of deaths in children under five years are due to diarrhea.

Emerging problems, which affect the environment and contaminate water sources, are: salinity, water – logging and soil degradation from extensive irrigation; discharge of agricultural and industrial effluents and urban waste; and use of agro-chemicals, including aerial spraying for aquatic weeds. The government's National Program of Action for Child Survival and Development sets the availability of 20 liters of safe water per capita per day within one kilometer from the user's dwelling as the acceptable standard. On average, urban populations consume about 20 liters per capita per day while some of their rural counterparts manage with only 8 liters per capita per day.

The NPA (National Program of Action) which is a governmental program for child survival and development, sets the goal of universal access to safe drinking water and sanitary means of excreta disposal by the turn of the decade. The present rate to expansion of services in rural areas does not keep pace with the growth of populations in need of safe water, implying that, unless these services are used cost-effectively, meeting the decade goals will not be possible. Only 40 % of urban population has access to safe water and investment in provision of services not commensurate with growth in need.

Sanitary excreta disposal is difficult in many areas. The 1993 census data indicate that one out of two rural, and about one in five urban Sudanese have no access to means of sanitary excreta disposal. As with access to safe water, differences within the country are evident.

In rural areas, women and girls bear the main responsibility for collecting water. During the rainy season, women collect water from natural depressions, shallow dug wells and seasonal streams. In the dry season they are forced to walk much longer distances to search for water, albeit from contaminated sources. When the source is distant, the task may take about four to eight hours and consume one-third of their daily nutritional intake, undermining their health. Some times; young girls are withdrawn from school to help their mothers in such chores at the expense of their education.

Wells, surface water forms, rivers, and stored rainwater are the main sources of drinking water in both urban and rural areas of the Sudan. The most important surface water source is the Nile River and its tributaries. In the cities and towns along banks of rivers, surface water is treated and piped. Rainwater, besides being consumed directly, is channeled through Hafirs or Folas (hand-dug water catchments and natural ponds, respectively).

2.1.1 Health & Water:[13]

Water services, in Sudan are far behind the WHO standards in terms of quantity and quality. Acute water shortage is a common phenomenon in many urban centers. In rural areas water sources when available they are in most cases not accessible and people have to walk for long distances searching for water.

Water related diseases, as Balharsia, Gardia, Trachoma, etc. are widespread. Guinea worm represents a real threat to surface water sources especially in southern states where there are no other sources.

Based on the fact that (any water is better than no water) Sudanese water quality standard should be looked to as a compromise between available water and their health impact. Water supply, sanitation, and hygiene education should be considered as one Package.

Guinea worm disease is a crippling water-borne disease, with severe impact on health, agricultural output, school attendance, and general socioeconomic status of the affected areas. Sudan is reported to be the most endemic country, hosting 60% of the world's cases, spreading in 6,493 villages by the end of 1998, mainly in the southern regions and the boarding northern states. Eradication rates estimated to account for 6 % for the first half of 1999.

2.1.2 Water resources and water supply sources [3]

2.1.2.1 Water Resources:

The available water resources comprise the Nile system, rainwater, and groundwater.

- The Nile system is the surface water source from where the majority of the urban population satisfies its domestic water demands. The main Nile and its major tributaries provide perennial and fresh waters of good chemical composition. The minor tributaries as Rahad, Dinder, and Bahr el Arab used to dry up, in the dry season leaving stagnant pools. The Blue Nile is characterized by seasonal water level fluctuations and turbidity increases to over 16,000 ppm during flood times creating filtration and

disinfections problems. The White Nile though of homogeneous composition and steady levels has high colloidal matter. The irrigation canals of Gazira, Rahad, and new Halfa schemes are an important water source. They show signs of organic contamination and they are a source of Belharazia, Dysentery, and Malaria. During dry period and due to siltation and crop rotation they don't provide water.

- Rainfall, though vulnerable and short lived is an important water source especially a long the savannah belt. Deforestation, over the Wadi catchments areas, has resulted in increasing siltation process. Most of the rainfalls are lost due to evaporation and infiltration. Rainwater is sensitive to short climatic changes.

- Ground water represents; under the arid conditions; the main water resources especially in rural areas. Ground water, in most cases, does not respond to short and medium term drought periods. Groundwater of different qualities can be extracted from different depths, under 70 % of the country. Major groundwater basins exists in sedimentary rocks of the Nubian, Um Ruaba, and alluvial deposits. Groundwater resources are estimated to be about $900*10^6$ m^3 with an annual recharge of around $4*10^6$ m^3. The annual consumption is around $1.2*10^6$ m^3. The following geological formation (figure 2.1) determine its availability:

    - ***Nubian sandstone formation*:** covers about 25 % of the North, West and Central parts of the country. Boreholes need to be dug to a depth of about 200 – 500 meters; the water is of acceptable quality for drinking.

- ***Um Ruwaba formation*:** covers about 19 % of the area in the Blue Nile and parts of Darfour, Bahr Al-Ghazal and Equatoria. It is usually yields saline water at a depth of 100-500 meters due to poor stratification of sediments.

- ***Alluvial deposits*:** found in Nuba mountains, Gebel Marra, Red Sea Hills and Gash River where water levels are subject to fluctuation depending volcanic rocks which yield sizable amounts of water following good rains seasons.

- ***Basement complex*:** Covers more than 50 % of the geographical area, and yields water from weathered and cracked horizons in which hand pumps with small diameter boreholes can be successful, especially in the western, southern and central parts of the country (UNICEF, 1990).

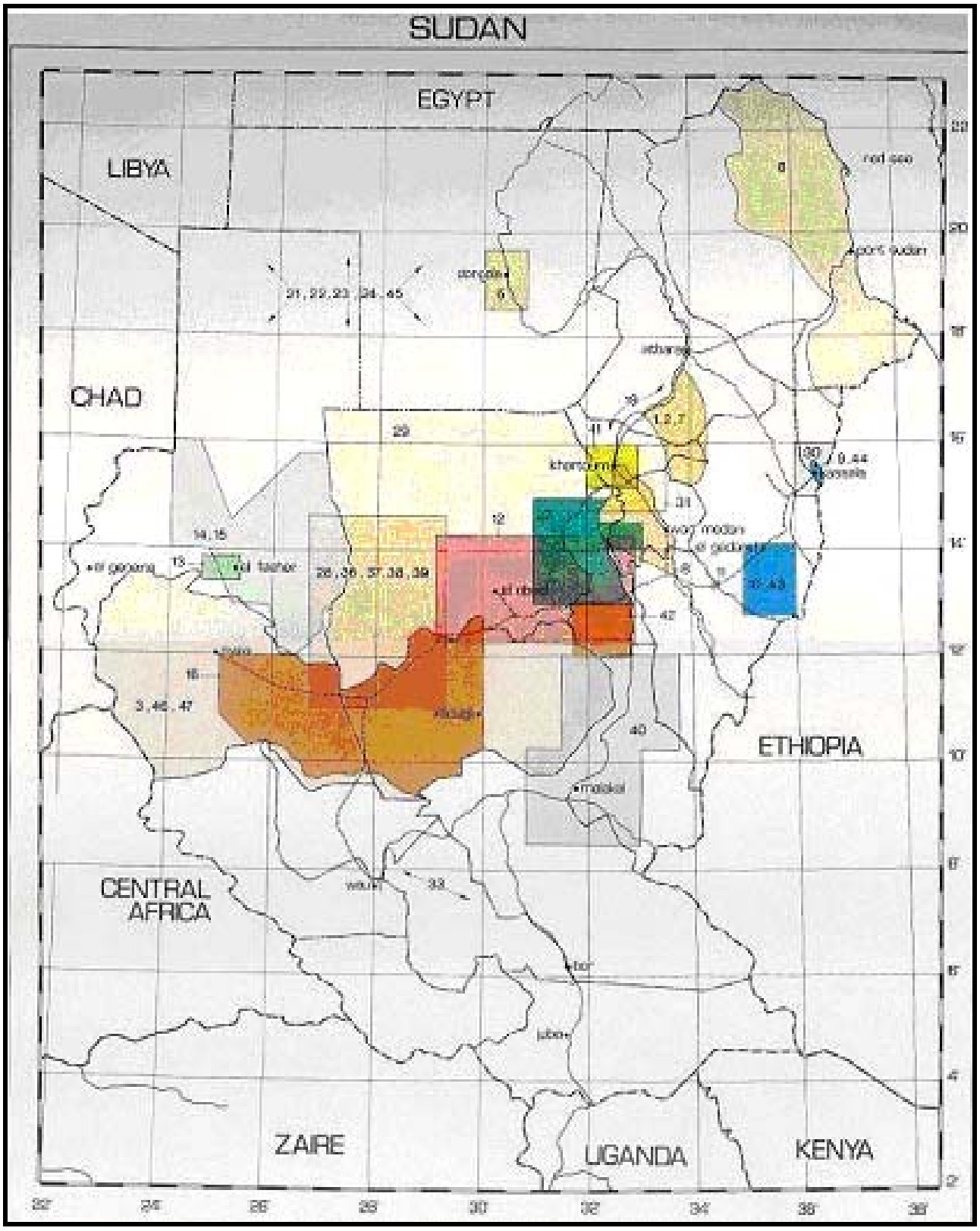

Figure (2.1): Sudan geological formation [1]

2.1.2.2 Water Supply Sources:

Water supply sources can be classified as traditional and improved water sources. Traditional water sources comprise surface water sources as Rivers, Rahad, pools and groundwater sources as Idds, mashes and temporary open shaft wells. In general traditional water sources do not provide reliable and safe resources.

Improved water sources include surface water treatment plants, Hafirs, and earth dams that use surface water resources, and deep boreholes (water yards), slim boreholes installed with hand pumps and permanent open shaft wells that use ground water resources. Water resources vary in types, capacity, and water quality.

2.1.3 Rural water sources

Rural water sources comprise:

- 4100 deep boreholes installed with diesel driven reciprocation or vertical turbine pumps forming water yards. Water yards are supplied with elevated storage tanks and water distribution facilities as public taps. Water yards, being concentrated in major sedimentary basins, provide good quality water in most cases.
- 13,000 slim and shallow boreholes installed with hand pumps for domestic supply for small communities.
- 1000 open shaft wells where water is drawn by plastic buckets and / or leather buckets tied to a rope drawn manually. Open shaft wells water is used both for human and livestock and can be easily contaminated during handling. Open shaft wells are subject to surface contamination and they are mostly sensitive to midterm droughts.

- 1100 Hafirs and earth dams distributed in the clay plains of the savannah belt. Hafirs and earth dams are sensitive to rainfall variability. In most cases and due to mal fencing, animals can enter and wade in, as well as Hafir water is subject to surface contamination and bacterial growth and they are mainly used for livestock watering. Hafir in general do not provide safe water.
- 338 Nile and canal filters. They are mainly concentrated in basement areas as well as in irrigation schemes. Due to discontinuous maintenance they mostly provide raw water.

Majority of existing water yards and Hafirs were constructed during the anti-thirst campaign (1969-1972) and they are approaching the end of their useful lifetime. Water yards need to be replaced and Hafirs suffer from problems of sand encroachment, bank erosion, siltation and partial filling.

The capacity of all the improved rural water sources is estimated to be 300,000 m^3/day. Assuming that 50% of the livestock depends on such sources. This brings the per capita consumption to about 5 liters/day. Under the prevailing economical and managerial conditions even this quantity cannot be guaranteed due to frequent stoppage. The rest of human population need is mostly met from distanced and polluted traditional sources. The rural water supply situation largely affects the weaker group as women, children, and displaced populations.

2.1.4 Urban Water Sources that Comprise (62 towns):

- 44 water treatment plants use Nile water as well as rainwater that collected in Hafirs and earth dams. Water treatment plants along the Blue Nile and river Atbara banks sides suffer from problems of water level

fluctuation during summer and high water turbidity in flood season. Turbidity decreases the filtration capacity and hampers disinfections techniques. With the exception of Khartoum, majority of towns are supplied with raw water most of the year.

- 400 deep boreholes installed with electrical submersible pumps and about 50% of them were located in Khartoum town.
- Groundwater for the urban centers is mostly provided without any treatment in most towns. Towns like Obeid, Gadarif, and Portsudan suffer from acute water supply shortage due to major available resources in addition to management problems.

About 35% of the population entertain house connections, 40% depend on public water taps, and the rest 25%, living in squatter areas, depend on water vendors and polluted traditional sources. The person consumption, in urban centers, varies from a minimum of 10 liters to maximum of 100 L/d.

2.1.5 Access to Water [8]

The government's National Program of Action (NPA) for Child Survival and Development sets the availability of 20 liters of safe water per capita per day within one kilometer from the user's dwelling as the acceptable standard. A clear national definition of what constitutes a safe water source is yet to emerge.

The 1993 census revealed that the water supply networks covers almost 65 % of the urban population, either within their homes or from public water taps, whereas only about 20 % of the rural population draw their water from this source. Water from the other sources enumerated by the census and reflected in table (2.1) is generally considered as unsafe for drinking.

Table (2.1): Percent of population with access to different water sources

Source	***Northern State***			***Southern States***
	Rural	Urban	Total	Urban
Pipe connections	19.62	65.81	35.83	7.02
Well, donkey	56.12	20.25	43.93	55.16
River, Turaa	14.09	2.25	10.06	30.01
Tanker	4.78	0.59	3.35	0.24
Haffir, fola	1.36	7.17	3.34	5.40
Others	3.97	3.82	3.92	1.74
Not stated	0.00	0.11	0.08	0.43
Total	**100.00**	**100.00**	**100.00**	**100.00**

Source*: derived from 1993 census of Sudan Advanced Sample Tabulations, volume 3, Table 44 & final Tabulations, Southern States, Table (1.5)*

Marked differences are seen between rural and urban access to safe sources of drinking water, as well as in amount of water consumed, the cost to the consumer and source of supply. On an average, urban populations consume about 20 l/c/d at a cost of about 2 Sudanese pounds per liter. In contrast, some of their rural counterparts consume 8 l/c/d with two and a half times the cost, which is 5.5 l/c/d (subgroup on Human Resources Development, SN, 1995). Disparities exist among the different regions, of the country, with people in the Darfour region consuming less than one-forth the amount of water per day used in Khartoum town. Populations in peri-urban areas and in newly emerging urban centers may represent more than 35 % of the total urban population and generally lack access to safe water. Many are depending on vendors who transport water from distant communal sources. At times of scarcity the cost of water from such sources can rise to

high levels. Therefore, peri-urban areas and small towns emerge as a distinct priority with high need.

2.1.6 Government Polices and Strategies [2]

The NPA sets the goal of universal access to safe drinking water and sanitary means of excreta disposal by the turn of the decade. The Comprehensive National Strategy gives priority to the following strategies for achieving the set goal:

- Cost-effective utilization and management of water resources.
- Introduction of low-cost appropriate technologies and encouragement of local production of equipment;
- Rehabilitation of deteriorating water resources and systems;
- An expanded program of well-drilling and hand pump installation, especially in priority rural areas;
- Training, capacity building and increased use of domestic technical resources, to raise cost efficiency and reduce dependence on external resources;
- Development and expansion of sanitation services;
- Increased community involvement in planning, execution and management of water supply and sanitation services, and encouraging cost sharing and self-help;
- Encouragement of research aimed at better water resources management, evaluation of existing water yards, expanding low-cost technology options (hand pumps) and improving surface water sources (rain water harvesting, Haffirs, etc)

The priority in urban areas is to restore existing water works to their original designed outputs, followed by rehabilitation of other sources and expansion of services, especially in Khartoum and the sixteen state capitals recently upgraded from towns to cities.

2.1.7 Rural Water Supply [1]

The main sources of drinking water for the rural population of Sudan include ground and surface water. The groundwater sources primarily comprise deep boreholes equipped with motorized pumps called water yards, slim boreholes with hand pumps, and hand-dug wells; the surface water supply sources comprise the seasonal runoff catchment's reservoirs called Haffirs, and limited scale filtration plants constructed along the Nile (Rahad Scheme). However, these sources are not available for the majority of rural households, which rely on ponds, untreated water from rivers and other unsafe sources of surface water.

Water from Haffirs and dams is usually unfiltered and is considered unsafe source of drinking water.

Livestock are also watered from the same sources and consume about 40% of available supplies. Water yards are the predominant source of drinking water available to the rural population. At times of scarcity and drought they attract large numbers of people and livestock from surrounding areas. The majority have greatly deteriorated due to old equipment, shortage of spare parts and consumables, the dated centralized management systems and lack of community participation. Available surface water supply systems have declined as well. Many of them are operating at 40 % of their designed capacity while some are not functioning at all due to lack of maintenance and management. Most of deep boreholes were drilled in the

early 1970's during the anti-thirst campaign and their design did not suit the geological conditions and requirements of each formation. The nature and carrying capacity of the area and soci-economic factors were not considered. Gravel packing was not adopted and the filters used were one size slotted steel pipes size 1/16". As a result, most of the boreholes drilled in Um Ruwaba formation have experienced frequent stoppage due to infiltration of sand into the borehole. A large number of the pumps were installed; the low efficiency reciprocating pumps, which are now obsolete and inappropriate for water production. The required spare parts for such technology are expensive and not readily available. In addition, centralized management of geographically dispersed water systems, which prevailed until the recent decentralization, precluded effective supervision, raised costs and proved ineffective.

Maintenance of the bigger capacity surface reservoirs was constrained by the high density of the silt accumulation and because of difficulty in use of earth-moving equipment for desalting.

As a result, the daily per capita consumption of water from the above sources falls far below the standard 20 liters specified in NPA and is as low as 4 liters in the arid western regions of Darfour.

2.1.8 Investment in Rural Water Supply [1]

The targets and achievements for the three-year program (1993-1995) under the National Comprehensive Strategy are reflected in table (2.2).

Table (2.2): Rural water supply, 1993-95: targets and achievements

Services	*Targets*	*Achievements*
Deep boreholes	1100	255 (23%)
Boreholes with hand pump	3500	2450 (70%)
Dug wells	300	120 (40%)
Construction of the Haffirs, dams	462	21 (04%)
Construction of filtration plants	85	14 (16%)
Installation of water yards	600	90 (15%)
Rehabilitation of Haffirs, dams.	150	35 (23%)

* ***Source:*** *Subgroup on Human Resources Development, CSN*

The high rate of achievement in the hand pump program (70%) is attributed to the technology option, which proved to be appropriate and cost effective. Effective community participation and adequate foreign assistance from UNICEF for purchase of offshore supplies and equipment commensurate with plans were additional factors.

The low rates of achievement of the water supply schemes are a result of the high cost of executing such utilities, shortage of foreign and local resources, and limited community participation in these high cost technology options.

In 1993, the total investment in the rural drinking water supply was estimated at the equivalent of about 11.8 million US$, of which 63 % was external assistance, 20 % was contributed by NGOs, 10 %, by user communities and 7 % by the government. Investment trends declined sharply in the 1990s; the estimated investment from all resources decreased from about 35 million US$ in 1990, a figure that includes substantial special funds contributed in response to the severe drought, to a round 9 million US$ in 1994.

The major external donors in 1991 – 1995 for the rural water supply program were UNICEF, UNDP, DANIDA, CARE, SCF (USA), SCF (UK), ADRA, the German Credit Bank KFW (Kreditanstlt Fur Weidanfban) and IRISH AID (Republic of Ireland). UNICEF assistance averaging about 5 million US$ a year, according to the priority of drilling boreholes with hand pumps, especially in guinea worm endemic areas, sanitation, hygiene education and community participation. UNDP, in collaboration with ILO and the Area Development Scheme (ADS), supports the construction of the manual reservoirs, dug wells, drilling of boreholes with hand pumps, and provision of latrines in Kordofan, Darfour, Eastern and Northern regions at a cost of about 5 million US$. Foreign assistance was phased out in 1993 and work now proceeds under the food-for-work program. CARE International and SCF (USA) collaborates in Kordofan region in the rehabilitation of water yards and construction of dug wells, manual reservoir and latrines. Financial support for the farmer has ceased, while the later set of activities are continued with Food–for–Work, SCF (UK) collaborates in similar activities in north Darfour with SUNDOS (Special United Nations Drought Operations for Sudan) funds and Food-for-Work. ADRA collaborates with the National Water Corporation and UNICEF in the provision of hand pumps sanitation and hygiene education in Khartoum and central regions, while DANIDA has provided a total of 34.0 million DK (6.3 million US$) for rehabilitation of water yards in central and northern regions. KFW of German is another major external partner who has provided 15.4 million DM (11.1 million US$) for construction of well fields and pipe lines for refugee populations in central and eastern regions and for construction of 42 water yards in northern and central regions. IRISH AID is expected to assist with offshore supplies for rehabilitation of 21 water yards in 1995-1997.

Cost-sharing by the user communities is primarily linked with the water yards, though it has now been introduced for other schemes implemented with UNICEF cooperation such as hand pumps, rapid sand filtration systems, etc.

In the case of water yards frequent revisions are undertaken to adjust tariffs with the increasing costs. The main elements considered in determining rural tariffs are the fixed and running costs of the utility. The fixed costs primarily comprise depreciation and marginal interest, whereas running costs include labor, fuel and lubricants, repair and maintenance and administrative overheads.

The rural tariff has increased from 16.5 Ls per cubic meter in 1992/93 to 137.5 Ls in 1993/1994 when federal subsidies withdrawn and rates were revised to reflect all costs mentioned above. In earlier years, no depreciation was considered and operational costs were subsidized. The impact of these cost-recovery systems on utilization of the services provided, especially by the most vulnerable and the poor, is yet to be studied.

2.1.9 Projection Needs:

The present rate of expansion of services does not keep pace with the growth of population in need of safe water, implying that, unless there is a significant increase in the resources invested in the sector, and unless they are used cost-effectively, meeting the decade goals will not be possible.

The expansion in services needed to increase access rates to at least 75 % are estimated to require an additional investment of about 329 million US$ (Table 2.3).

Table (2.3): Services required to provide universal access: rural

Type of Source	Number	*Unit Cost (US$ 000 s)*	*Total Cost (US $ 000 s)*
Drilling of deep boreholes	4.000	20.00	80.000
Pumps and other installations	5.000	25.00	125.000
Rehabilitation of water yards	2.000	25.00	50.000
Slim boreholes with hand	40.000	0.40	16.000
Dug wells	10.000	.020	2.000
Surface reservoirs and dams	3.000	15.00	45.000
Rehabilitation of surface	2.000	5.00	10.000
Filtration Units	2.000	0.30	600
Total			**328.600**

* Source: National Water Corporation

2.1.10 Urban Water Supply:

Roughly one third of Sudanese people lives in towns and cities. The last decade has witnessed a surge in rural-urban migration due to a combination of regional imbalance in development investment and availability of services and employment, the impact of the severe drought in 1989-1991 and displacement due to the civil conflict. The 6.8 million urban population of north Sudan lives in 46 major towns and cities. There are 23 towns with a population of 20,000 – 50,000 and additional 23 with populations greater than 50,000. Khartoum town with a population of 2.9 million residents (according to the 1993 census), account for 43 % of the urban dwellers in north Sudan.

The country's goal is to provide water through water supply network to 85 % of the urban population by 2002, with the balance of 15 % being served by public stand posts. Against this target, in 1993, 45-47 % of the

urban population had access to private connections, while 15 % were served with public stand posts.

However, when the quantity of water available is considered against demand, the gap is wider and increasing due to urban population growth (Table 2.4).

Only 40 % of the urban population has access to safe water and investment in provision of services is not commensurate with growth in need. About 12 major urban water supply schemes, which are under way, which will, when completed, provide an additional 230, 600 m^3/day. They are for the towns of Khartoum North, Edduweim, Kosti, Gaziera Aba, Renk, El Damazine, Wadi Halfa, Karima, El Obied, Khashm Algirba and Bara. A further seven projects (for El Fasher, El Gadarif, Port Sudan, El Damer, Khartoum, Nyala and for rehabilitation and extension of existing waterworks) are planned as part of the national strategy and program.

Table (2.4): Demand for urban water

Region	***Capacity*** *(m^3/day)*	***Population***	***Demand*** *(m^3/day)*	***Coverage*** ***%***
Khartoum	350.000	2,929,773	700,000	50
Northern	30.000	296,684	64,000	47
Eastern	48.000	1,030,198	205,000	20
Central	80.000	1,280,761	184,000	39
Kordofan	23.000	649,962	114,000	17
Darfur	14.000	652,523	74,000	20
Southern	20.000	674,210	103,000	16
Total	**565.000**	**7,504,11**	**1,445,400**	**39**

* ***Source****: National Water Corporation*

The capital costs of provision of services are financed through the development budget of the federal and state governments, with community contributions, while operation costs are recovered through the levy of a tariff.

Special commercial rates are charges for industrial and commercial enterprises. Leakage, losses through burst pipes, use of water for fire fighting and illegal connections are significant contributors to water losses that in many urban areas can reach 40 %.

Institutionalized community contributions to urban water supply are quite recent. Communities contribute either in kind (usually labor), or make monetary contributions. As a result of a recent policy, contributions for capital investment are recovered as part of the initial value of residential plots. Tariff rates are calculated on the basis of operating costs and depreciation, and include a profit on capital cost and a 4 % margin of profit. Since most of water meters are out of order, a flat monthly fee is levied depending on the size of the connection: 850 Ls per month for 1/2 ” connection, 1,000 Ls for ¾ “ connections and 1,500 Ls for 1” connections. Water rates are revised once every six months to keep a breast of inflation.

The additional resources required to expand services in urban areas and meet the goals envisaged are estimated at 331 million US$. The proposals imply high expectations from external resources: 263 million US$, or 80 % of the requirement. Some 6 million US$ is the estimated requirement for immediate rehabilitation measures, while 200 million US$ is the projected short term demand for additional services, with a further 125 million US$ being required for medium term expansion of services. [3]

2.1.11 Sanitation [3]

Sanitary means of excreta disposal are scarce. The 1993 census data indicate that one out of two rural, and about one in five urban Sudanese have no access to means of sanitary excreta disposal (Table 2.5).

Pit latrines are the predominant type of facility used, and for the most part are constructed by users with no financial assistance from the government. Only parts of greater Khartoum are covered by a water-based sewerage system.

Table (2.5): Percent population with access to sanitation facilities

Types of services	*Northern States*			*Southern States*		
	Rural	*Urban*	*Total*	*Rural*	*Urban*	*Total*
Community sewer	0.2	2.0	0.8	N/A	0.5	N/A
Pit Latrine	38.5	56.9	44.7	N/A	22.5	N/A
Others	14.5	19.2	16.4	N/A	25.6	N/A
None	46.4	21.9	38.1	N/A	51.4	N/A
Total	100.0	100.0	100.0	N/A	100	N/A

* ***Source***: *Derived from 1993 census of Sudan advanced sample tabulations Volume 3, Table 43 and Final Tabulations, Southern Sates, Table U4.*

Ventilated improved pit (VIP) latrines which have been introduced in rural areas over the past few years are propagated, with hygiene education, under the UNICEF assisted water supply and sanitation projects, the WHO supported Blue Nile Health project, and through the efforts of many NGOs like Save the Children Fund. The total coverage by VIP latrines is estimated at around 6 % of the rural population in north Sudan.

As with access to safe water; differences within the country are evident. More than 50 % of the population in eastern and central regions has no

access to any sanitary facilities, compared to 15 % of the population in Khartoum.

Urban sanitation facilities are fully financed by the house owners except for community sewerage systems, which are financed through the government budget. The operation and maintenance costs of such systems are to be recovered from users through the levy of charges. No records are available of significant government funding for rural sanitation. The limited coverage available is mainly due to the externally aided projects of WHO, UNICEF, the Netherlands, and international and national NGOs. Community contribution and participation are integral part of these initiatives.

2.2 Water Quality [12]

Survey in Sudan showed that 44.48% of population has access to drinking water supply, whether safe or not, no body knows, because of the lacking of monitoring and surveillance program in addition to the absence of laboratories in the states. Only few surveys were made for specific purposes. Sampling and analysis is carried out for new sources of water. When there are health problems, sanitary inceptions and remedial measures are taken. There is no information network and no field testing kits. The water quality control is the responsibility of Drinking Water Corporation, where the ministry of health is mainly responsible for water surveillance system.

There are 726 public health inspectors and 2400 sanitary overseas distribution all over the localities in the country, who represent basic infrastructure to do monitoring and surveillance system. Surveillance is an investigative activity undertaken to identify and evaluate factors associated with drinking water could pose a risk to health.

Surveillance contributes to the protection of public health by promoting improvement of the quality, quantity, coverage, cost and continuity of water supplies. It is also both preventative detecting risks so that action may be taken before public health problems occur, and remedial - identifying the sources of outbreaks of water - born diseases so that corrective action may be taken promptly.

Brief description is given below for the water quality parameters that have been found in excessive level than recommended by WHO guidelines.

2.2.1 Turbidity:

Turbidity is a measure of the suspended particles such as silt, clay, organic matter, plankton and microscopic organisms in water which are usually held in suspension by turbulent flow and Brownian movement. The amount of solid materials in suspension in water may result from natural erosion, runoff and algal blooms. High turbidity reduces photosynthesis of submerged, rooted aquatic vegetation and algae; this reduced plant growth may in turn suppress fish productivity. Water with a turbidity of 5 N.T.U or less is acceptable for drinking. High turbidity adversely affects domestic, industrial and recreational uses of water. Often some of this suspended matter has to be removed prior to domestic and industrial uses, since highly turbid water are abrasive to pumps, pipes, and turbine blades. Turbidity puts an excess load on water treatment plants by interfering with disinfection and generating extra sludge.

2.2.2 Hardness

Hardness is principally determined by the sum of calcium and magnesium. Water hardness relates to water's capability to produce lather from soap. Hardness is normally expressed as an equivalent of calcium carbonate ($CaCo_3$).

The range of hardness can be outlined as in Table (2.6).

Table (2.6): Hardness of Fresh Water

Hardness as Calcium Carbonate mg/l	**Degree of Hardness**
0 – 30	Very soft
31 – 60	Soft
61 – 120	Moderately Soft
121 – 180	Hard
> 180	Very Hard

The hardness of water varies according to local conditions. Water in areas of carbonate bedrock is characterized hard, whereas waters draining igneous rocks are very soft. The degree of hardness of water may have a detrimental economic impact; water with hardness less than 120 mg/l calcium carbonate can be deemed desirable for most uses, but only if hardness exceeds 500 mg/l the water can be labeled undesirable for both industrial and domestic uses.

2.2.3 Chloride

Chloride is a major inorganic anion that occurs in variable concentrations in natural waters. Chlorides may be found in sulphatic and calcareous deposits. The weather and leaching of sedimentary rocks and solids release chlorides to water. No adverse human health effects result

from the presence of large quantities of chloride (600 mg/l). Most domestic, agricultural and industrial uses require chloride concentrations of less than 250 mg/l. Chlorides are not removed by filtration in conventional physical water treatment methods.

2.2.4 Nitrates

Nitrate (NO_3^{-1}) is the principal form of combined nitrogen found in natural waters. Most surface waters contain some nitrates; however, the presence of nitrates in concentrations greater than 5 mg/l may reflect unsanitary conditions, since one major source of nitrates is human and animal waters. The consumption of waters with high nitrate concentrations decreases the oxygen, carrying capacity of the blood. This is important in the health of young infants. To protect young infant's concentration of nitrate should not increase 10 mg/l.

Chapter 3

Materials and Methods

3.1 Study Area [6]

The White Nile State lies in the middle of Sudan (figure 3.1), in the Eastern and Western banks of the White Nile River in an area of 31,000 squared km, it extends from semi-desert in the North (Shibh Alsahraa) to the rich Savanna in the South. The annual rainfall varies between less than 200 mm in the North and more than 500mm in the South. And rains are characterized by being swinging (30-40 %) and the rainy season being short especially in the northern part of the State

The White Nile State and its capital Rabak are divided into four provinces; Kosti, Edduweim, Gitaina and Jabalain and it constitutes 23 localities, 17 are rural and 6 are urban. The population of this state is about 1.5 million people, 62% in the rural areas and 38% in the urban and semi-urban areas. The State accommodates a considerable number of displaced populations from the civil war in Southern Sudan and some others are victims of drought in Western Sudan. Population density is concentrated in the Nile towns. Most of citizens earn their living by working in agriculture, animal pasture, and by working in agricultural schemes and factories and poverty is spread among them.

The State is located in the central part of Sudan, which makes it a crossroad of many highways, railways and river transport, which link Western and Southern State with the central State and the national capital.

The State accommodates the two largest sugar factories and the second largest cement factory in Sudan; these are beside edible oil, soap and cheese

factories. There are also a number of irrigated agricultural schemes and mechanized rain fed schemes as well as traditional farming, it is also considered one of the richest states endorsed with animal wealth.

The Southwestern part of the State is located within the White Nile groundwater aquifer, which is constituted of Um Rawaba rocks. The Northern part is located within the Blue Nile groundwater aquifer, which is constituted of Nubian rocks, and these two are separated by Elatshan-Elarashkol depression. Mahboba basin, which extended south to Rabak; the natural link between the two basins.

Geo-morphologically and ecologically the State is divided into two belts, the River Belt and Hinter Lands belt. The last one is divided into clayey valleys in the South and sand dunes in the North.

The ground surface of the study area is flat and is constituted of the clayey valley extend toward the south and at the two sides of the White Nile river and sand dunes in the North. The State generally is characterized by the deterioration of its renewable natural resources base.

Drought, desertification, floods and industrial waste are the most challenging environmental hazards.

خارطة توضح مشروعات المياه بجنوب السودان والمناطق التى امتدت اليها الحرب

المفتاح

الموقع	الرمز	الموقع	الرمز
محطة مياه الرنك		الآبار السطحية	
محطة التنقية الصغيرة		الخزانات الأرضية (حفائر)	
الآبار الجوفية			

Figure (3.1): Study area location in Sudan

3.2 Methodology

1-Collecting many types of data; social, economical and technical to determine first: Population, the economical activities, animal resources, agriculture, use of land, available water resources and sanitation facilities (in urban, semi-urban and rural areas).

2- Choosing samples of villages to get water samples and do water analysis (at least bacteriological analysis)

2- Collecting data about water resources management and the constrains that are facing the improvement of water and sanitation services in the state.

3-Try also to have an overall look on the administrative issues, activities, water and sanitation projects and the situation of it's services.

4-Analyzing all these above mentioned data for year 1999 to determine the total needs of water and sanitation services in the state for year 2005, 2010 and 2015 with the help of available water resources and sources data. Also to determine the water quality in the different provinces.

4- Try to put strategic recommendations for improving water and sanitation services in the State.

3.3 Methods of Analysis [4]

3.3.1 Population forecasting:

The knowledge of population forecasting is very important for the design of any water supply scheme. The design is done on the basis of projected population at the end of the design period. Otherwise a present scheme will be inadequate in near future. There are many methods of population forecasting adopted in practice. Some of them are described below:

3.3.1.1 Arithmetical increase method.

This method is generally applicable to a large and old city, whose scope of further expansion has reached to saturation limit. For small, average or comparatively new cities, if this method of population forecasting is employed, we shall most likely get low result than actual value. In this method the average increase in population per decade is calculated from the past census reports. This increase is added to the present population to find out the population in the next decade. This method of forecasting gives satisfactory result for old and large cities.

3.3.1.2 Incremental increase method:-

For an average size town under normal condition the growth rate is found to be in increasing order. In other words it may be stated that there will be increments in increase of population in each decade. While adopting this method the increase in increment is considered for calculating future population.

The increment in increase is determined during each decade from the past population along with the average rate of increase. Thus it improves the low result that is obtained by arithmetical increase method. In fact this method is a modification of arithmetical method.

3.3.1.3 Geometrical Increase Method.

In this method the percentage increase is assumed to be the rate of growth of the town under consideration. Average percentage increase is used to find out the future increment in population. This method gives higher values and should be applied to a new industrial town at the beginning of development only for few decades. This high rate of

population growth lasts even for a new industrial town for two to three decades and does not continue, but the percentage increase-decreases considerably afterwards.

3.3.1.4 Decrease rate of growth.

It has been discussed earlier that the geometrical rate of growth gives higher result and any city's population curve will not follow in geometric pattern beyond two to three decades. Later on the rate falls down. in decrease rate of growth method the fall in percentage increase is considered and then the future population is determined. So this method can be termed as a modification of geometrical increase method. This method is applicable to average size cities growing under normal condition. This may also match with the rate of growth beyond the initial decades of new industrial town i.e. beyond the stretch after it has covered geometric rate of growth.

3.3.1.5 *Graphical method.*

In this method the population curve (the population vs. year) is smoothly extended for getting future population. This extension should be done carefully and it requires proper experience and judgment. The best way of applying this method is to extend the curve by comparing with the population curve of some other similar cities having the similar condition of growth. (Equation 2.1).

$$P_n = P(1+r)^n \quad \text{..... (Equation 2.1)}$$

$P_n \equiv$ Population estimation after n years.

$P \equiv$ The last population estimation.

$n \equiv$ Number of years.

$r \equiv$ Annual rate of increase.

3.3.2 *Water Demand:*

Before planning a water supply scheme, it is the engineering's duty to examine carefully the various types of water demand a city may have. The demand may be classified in the following categories:

1- Domestic water need
2- Institutional demand
3- Industrial demand
4- Fire demand
5- Water unaccounted for

It is important to assess each of the above demand to get an accurate and total picture of water requirement.

3.3.2.1 *Domestic water need*

Under this head the quantity of water required for various domestic usages, is ascertained. Domestic needs, such as bathing, drinking, cooking, flushing toilets washing etc. come under this demand. The population of a city or town will be most important factor, which will control the consumption of water under this need.

A minimum rate of 70 to 100 liters per capita per day (l/c/d) should be allowed for domestic need. The break up at domestic demand per day for a town per head basis may be assumed as given below:

(i) Water required for drinking	2 liters
(ii) Cooking, washing etc.	10 liters
(iii) For bathing, washing clothes	40 to 60 liters
(iv) Flushing water closets	25 liters
(v) Others	10 liters.

Total	70 to 100 liters

Depending on the relative importance, size economic conditions of a city, the rate of water demand will always be associated with non-domestic need also. The various aspects of non-domestic need will be discussed subsequently.

As a general rule, the following allocation of water for domestic and non-domestic need, will give a guideline for initial assessment for water.

(i) For communities with population up to 10,000	70 to 100 l/c/d
(ii) For communities with population 10,000 to 50,000	100 to 125 l/c/d
(iii) For communities with population above 50,000	125 to 200 l/c/d

The requirement of each case will have to be studied with reference to the local factors governing the different needs before the optimum rate of supply for the community is decided upon.

In case of rural communities where house service connections are not contemplate and the supply may be through hand pumps or central stand posts, the rate will shall not be less than 40 l/c/d. Where house service connections are contemplated, to make the scheme self-paying the rate shall be at least 70 l/c/d.

3.3.2.2 Institutional demand:

This also sometimes known as public demand and it includes the quantity of water required for various public utility purposes. The water required for various public buildings and institutional, public parks, playgrounds, gardening, sprinklers on roads, street foundations etc. will come under this demand. For many water supply schemes, the latter parts are believed to be not essential and only a nominal amount is kept for this. But the demand of water for various public buildings and institutions is well recognized and a specific allotment is made for each. Table (3.1) shows the recommended water supply rates.

Table (3.1): Recommended water supply rates

No.	*Types of Institution*	*Recommended Rate*
1	Hospital including laundry	
	(a) Not exceeding 100 beds.	340
	(b) Exceeding 100 beds.	455
2	Hotels	180 (per bed)
3	Hotels	135
4	Restaurants	70 (per seat)
5	Air Ports and Sea Ports	70
6	Junction Stations	70
7	Terminal/Intermediate Stations	45
8	Day Schools/College	45
9	Offices	45
10	Factories	45
11	Cinemas/Theatres	15

3.3.2.3 Estimating of per capita Water Demand:

This is required for finding out the total water requirement of a town. This is done by finding out water need for each head as discussed above and additional of all these will give the gross water requirements. Water demand of different heads may be summed up, and the figure may be divided by the population of the concerned area, which will give equivalent per capita water demand. Thus both the domestic and non-domestic needs are expressed with relation to population. The following example may be useful for understanding of this statement. The break up of water consumption rates of a town under various heads may be assumed as

1- Domestic need	100 l/c/d
2- Institutional/Public requirement	20 l/c/d
3- Industrial demand	30 l/c/d
4- Fire demand	15 l/c/d
5- Water unaccounted for	35 l/c/d

	Total 200 l/c/d

From the above it can be seen that gross water requirement will be 200 l/c/d. If the total population of the town is ascertained, the water demand per day may be assessed.

There are certain factors which control the water consumption rate. For making a correct assessment of water requirement, they should be borne in mind.

3.3.2.4 Factors Affecting Water Consumption:

The rates of water consumption depend on many factors. They can be summarized as given below:

Climatic condition:

Climatic condition has great influence on water consumption rate. The water consumption rate in hot and arid regions will tend to increase as compare to wet and cold places.

Standard of living:

For cities with high standard of living, the water consumption will be higher. For poor class people the per capita demand of water is low.

Industries:

Water requirement not only directly depends on the nature, number and size of industries, but also their indirect relation to over all development. For industrial area water demand also should be properly linked with fire demand. In general, with the increase of industries water demand will rise.

Quality of water:

If the quality of water is good, the people will consume more water; otherwise they may avoid and try to use minimum quantity of water. So for safe and good quality water, water consumption will be higher.

Pressure in the distribution system:

If the pressure in the distribution system is high, that will cause not only high rate of flow, but also leakages also will be high, thus increase per capita demand.

System of sanitation:

If the towns are provided with water carriage system of sanitation, the per capita water increases.

Use of meters:

If the metering is introduced for the purpose of charging for consumed water, the consumer will be cautious in using water and there will be less wastage of water. So per capita demand may lower down. But, it is not only cost of initial capital investment, but also regular establishment and maintenance costs. Secondly too less use of water by the consumers may lead to unhygienic conditions.

3.4 Water Analysis Methodology

The process of taking samples and analyzing them took about 6 weeks and it included:

- At site measurements of physical parameters.
- Laboratory chemical analysis of elements including heavy metals.
- Bacteriological analysis.

This process is focused on identification of water quality from locations representing the different sources of water supply in the White Nile State. The White Nile State is divided into four provinces:

1. Kosti (كوستي) province
2. Edduweim (الدويم) province
3. Gitaina (القطينة) province
4. Jabalain (الجبلين) province

From each Province samples of water were collected to present the dominant source of water in the area. The analysis were performed in the Sanitary Laboratory of University of Khartoum for physical, chemical and bacteriological characteristics of water. The results obtained are discussed and mitigation measures are setout to alleviate water quality problems in specified locations of the State.

The following locations were selected in the four Provinces of the White Nile State for monitoring water quality of the respective water facilities.

Table (3.2): Kosti Province selected water facilities (محافظة كوستي)

No.	*Location*	*Water Facility*	*Remarks*
1	Abu Freiwah أبو فريوة	Borehole	Deep Aquifer
2	Um Hani ام هاني	Feeding Canal	Surface water (White Nile)
3	Gadid جديد	Shallow Well	Traditional Idd (عد)
4	Shargah El Mokashfi شارقة المكاشفي	Shallow Well	Improved Idd
5	El Hissay الحصي	Hand Pump	Shallow Aquifer
6	Tandalti تندلتي	Borehole	Deep Aquifer
7	El Kawah الكوة	Borehole	Deep Aquifer

Table (3.3): Edduweim Province selected water facilities (محافظة الدويم)

No.	*Location*	*Water Facility*	*Remarks*
1	El Alaga العلقة	Borehole	Deep Aquifer
2	Shabasha شبشة	Borehole	Deep Aquifer
3	White Nile	River	Surface Water
4	Ab Gimri أب قمري	Hafir	Surface Water (Rain Water)
5	El Mikeifi المكيفي	Hand Pump	Shallow Aquifer

Table (3.4): Gitaina and Jabalain Provinces selected water facilities (محافظة القطينة والجبلين)

No.	*Location*	*Water Facility*	*Remarks*
1	El Gitaina القطينة	Borehole	Deep Aquifer
2	El Beton البتون	Hafir	Surface Water (Rain)
3	El Shorak *الشراك*	Hafir	Surface Water (Rain)

The following physical, chemical and bacteriological parameters were tested for waters collected from the above mentioned facilities in the four provinces of the White Nile State, representing WHO guidelines. This step is

carried to assess the water quality in the study area and to indicate variations from guidelines

Table (3.5): Guidelines for Specific Parameters [1]

No.	*Parameter*	*Guideline (WHO)*
1		
	Physical tests	
	Turbidity	5 N.T.U
	Suspended solid	-
	Total Dissolved solid	1000 mg/l
2		
	Chemical Tests	
	pH	6.5 – 8.5
	Total hardness	180 mg/l as $CaCo_3$
	Calcium (Ca^{+2})	250 mg/l
	Magnesium (Mg^{+2})	50 mg/l
	Floruride (F^-)	1.5 mg/l
	Chloride (Cl^-)	250 mg/l
	Nitrate (NO_3^-)	10 mg/l
	Sulphate (SO_4^{-2})	400 mg/l
3		
	Heavy Metals	
	Iron (Fe^{+2})	0.3 mg/l
	Lead (Pb)	0.05 mg/l
	Cadmium (Cd)	0.005 mg/l
	Zinc (Zn)	5.0 mg/l
	Copper (Cu)	mg/l
	Manganese (Mn)	0.1 mg/l
4		
	Bacteriological Test	
	Total Coliform	0 col/100 ml
	Fecal Coliform	0 col/100 ml

Chapter 4

Data, Calculations and Analysis

4.1 Population [6]

According to the fourth national population census (1993), the total population in the State is 1,227,024 with an annual growth of 2.59%, and therefore the total population in 1999 was expected to be about 1,492,178 of which 61.8% in the rural areas and 33.5% in the urban and 4.7% in the semi-urban areas in the capitals of the localities which are recently established. The population is distributed among the four provinces of the State as follows; 43.5% in Kosti province, 21.6% in Edduweim province, 19.8% in Jabalain province and 15.1% in Gitaina province (Figure 4.1).

- Rural population which is 922,772 live in around 745 villages and 34.8% of them live in Kosti province,
- 24.7% in Edduweim province, 21.8% in Gitaina province and 17.8% in Jabalain province (Table 4.1).
- The average number of the village inhabitants in the State is 1,234. It increases in Asalaya and Kennana localities to (1,730 - 3,115) respectively. It decreases in Um Hani and Shaikh Sidig to (703 – 911) persons respectively.
- The percentage of 17.6% of the villages of the State are inhabited by less than 500 persons and 26% of the villages have inhabitants between 500 and 1000 persons, this means that 43.6% of rural villages in the state have less than 1000 people each.

- Population density increases along the Nile banks especially in Jabalain province which is the center for economic activity. The density is reduced beyond the Nile banks as a result of shortage of resources especially water resources and that leads to the population scattering which hinders the provision of services specially water services.

- Urban population, which is 499,876 live in 8 urban centers which are represented in the province headquarter beside the towns; Tendalti, Elkawa, Geziera Aba and Kennana which represent the localities headquarters (Table 4.3) this is beside 69,530 people who live in the semi-urban areas in the new locality headquarters (Table 4.4).

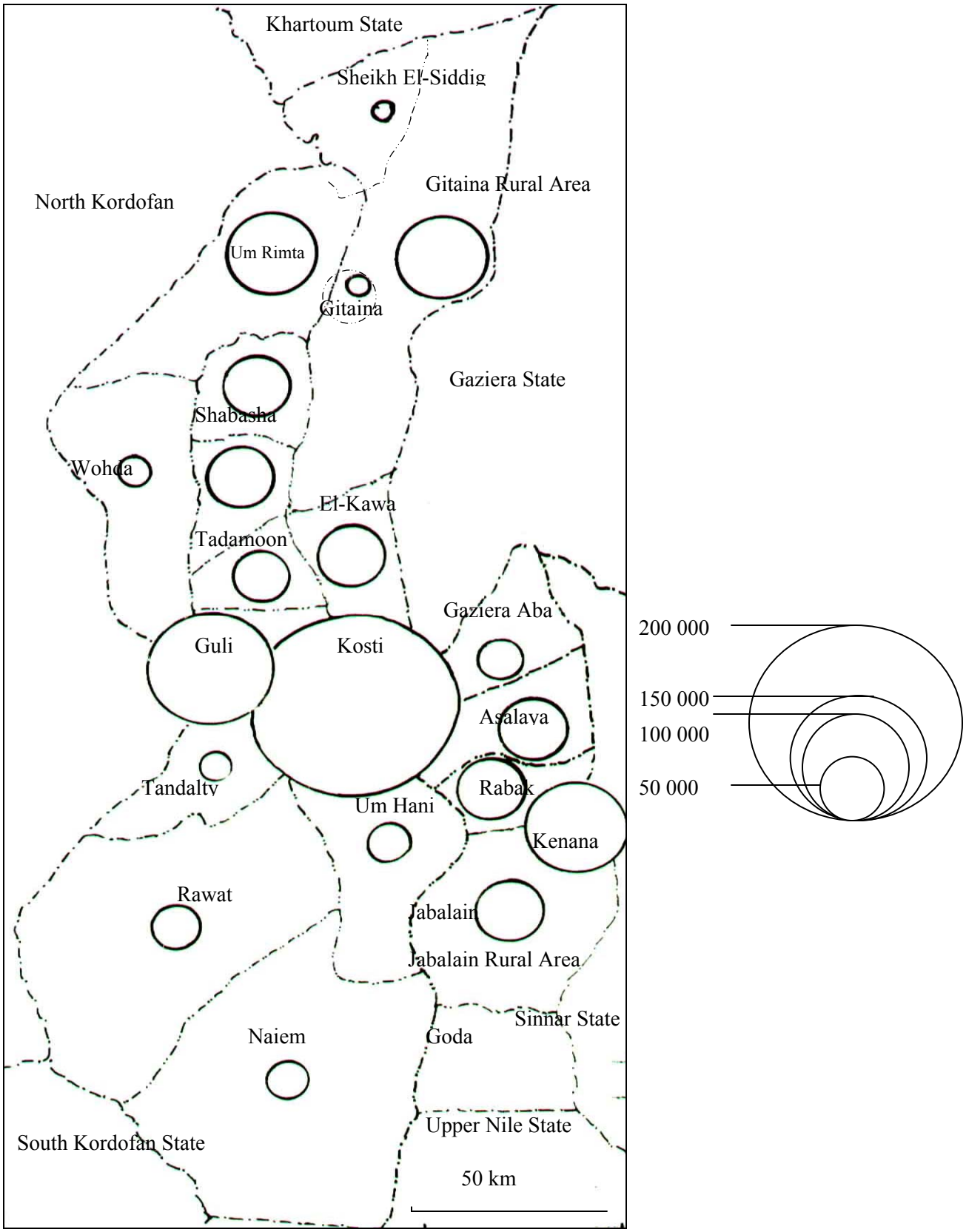

Figure (4.1): The State population distribution

Table (4.1): Rural population distribution 1999

Province	Locality	Population	No. Villages	Average population	No. # Of villages have population				No. # Of population in	
					Less than 5000	500-1000	1000-2000	More than 200	Smallest village	Largest village
Kosti	Tandalty	118,568	107	1,219	24	28	38	15	133	3,444
	Guli	121,654	99	1,229	24	25	34	16	150	8,053
	Um Hani	12,625	17	703	10	2	4	1	175	7,699
	Naeim	23,848	15	1,491	3	1	8	4	200	3,435
	Rawat	44,383	36	1,233	14	6	10	6	97	8,055
	Total	**321,105**	**275**	**1,159**	**77**	**62**	**94**	**41**		
DWM	Shabasha	68,769	34	1,298	7	17	22	6	270	12,036
	Tadamon	57,489	46	1,250	2	11	25	8	400	5,211
	Um Rimta	44,067	35	1,259	4	15	13	3	297	10,414
	Wohda	58,031	48	1,209	7	18	16	7	150	4,000
	Total	**228,357**	**181**	**1,255**	**20**	**61**	**76**	**24**		
Gitaina	Elkawa	66,831	59	1,133	14	14	26	5	50	3,000
	Shaikh Sidig	30,078	33	911	11	13	8	1	205	5,026
	Gitaina	104,197	99	1,052	20	33	37	9	35	4,100
	Total	**201,106**	**191**	**1,053**	**45**	**60**	**71**	**15**		
Jabalain	Gazira Aba	41,291	30	1,376	6	3	16	5	101	5,000
	Asalaya	31,145	18	1,730	0	3	7	8	581	8,435
	Kennana	59,183	19	3,115	1	1	4	13	225	10,352
	Jabalain	40,585	32	1,283	3	5	18	6	437	7,673
	Total	**172,204**	**99**	**1,739**	**10**	**12**	**45**	**32**		
Total		**922,772**	**745**	**1,234**	**152**	**195**	**286**	**112**		

Table (4.2): Semi Urban Population

Province	*Town*	*Population*
Kosti	Guli	8,053
	Rawat	5,713
	Naeim	1,753
	Um Hani	7,699
	Total	**23,218**
DWM	Shabasha	12,036
	Ziraiga	1,273
	Wad Nimir	10,000
	Um Jar	5,211
	Total	**28,520**
Gitaina	Shaikh Sidig	1,684
Jabalain	Asalaya	8,435
	Jabalain	7,673
	Total	**16,108**
Total		**69,530**

Table (4.3): Urban Population (1999)

Province	*Town*	*Population*
Kosti	Kosti	247,487
	Tandalty	58,000
	Total	**305,487**
DWM	Edduweim	65,862
Gitaina	Elkawa	5,372
	Gitaina	16,135
	Total	**21,507**
Jabalain	Gazeira Aba	23,448
	Kennana	15,114
	Rabak	68,458
	Total	**107,020**
Total		**499,876**

Table (4.4): The White Nile State population (1999)

Province	*Sector*	*1999*
Kost	Rural	321,105
	Semi-urban	23,218
	Urban	305,486
	Total	**649,810**
DWM	Rural	228,357
	Semi-urban	28,520
	Urban	65,862
	Total	**322,739**
Gitaina	Rural	201,106
	Semi-urban	1,684
	Urban	21,507
	Total	**224,297**
Jabalain	Rural	172,204
	Semi-urban	16,108
	Urban	107,020
	Total	**295,332**
Total		**1,492,178**

4.2 Animal Wealth [6]

The White Nile State is considered one of the richest States by animal wealth in Sudan, and referring to the Ministry of Animal Wealth estimations (1997), the State accommodates 6,850,480 cattle heads. The annual growth rates are, 4.5% for cows, 6.7% for sheep, 1.8% for goats and 1% for camels. These numbers are due to 1997 estimations and with these annual growths the number of the heads reached 7,458,000 in 1999 (Table 4.5).

Table (4.5): Provinces Animal Wealth Census (1999)

Province	*Animal Number (1000 head)*				
	Cows	***Sheep***	***Goats***	***Camels***	***Total***
Kosti	1,674	1,006	576	48	3,304
DWM	359	748	1,037	90	2,234
Gitaina	120	70	19	46	255
Jabalain	837	515	288	25	1,665
Total	**2,990**	**2,339**	**1,920**	**209**	**7,458**

** No estimations on localities level are found*

A considerable fish wealth along the White Nile River is found in the State which supplies the states towns and the national capital.

4.3 Land uses & Economic activities [6]

Agriculture and pasture represent the most important systems of land uses in the State and most of the population depends upon them.

4.3.1 Agriculture

- About 60% of the population depend on it and it constituted irrigated agriculture, mechanized rain fed agriculture and traditional rain fed agriculture (Figure 4.2)
- Irrigated agriculture is concentrated along the White Nile River. Its area reached 322,577 Feddan in the year 1998 of which 30.5% in Kosti province. Until recently, cotton was the main crop in the irrigated areas, but later sorghum and wheat become the dominant crops.
- The irrigated sector suffers from administrative problems, shortage of irrigation water and productivity deterioration. Currently rehabilitation of many schemes is underway through financial support from IFAD.

- Jabalain province and Rawat locality at Kosti province are considered the most important mechanized agriculture regions where 1.8 million Feddans are cultivated, 83% are cultivated by sorghum, the rest by sesame and other crops. This sector plays an important role in food security for the State population whereas crops market in Rabak has a considerable share in the State income.
- Shortage of drinking water and the deterioration of soil are considered the main obstacle for the mechanized agricultural sector development in the State.

4.3.2 Pasture

- The White Nile State is considered one of the richest States in Sudan in term of animal resources (7.5 million heads). It effectively contributes in supporting the Federal and State incomes. It also participates in providing meat, milk and its products and animal skins.
- Rabak and Kosti towns are among the most important livestock markets in Sudan. The State is a main passage for commercial livestock specially cattle arriving from the Southern and Western States to the markets of the middle States, Khartoum and exporting harbors.

4.3.3 Other Economic Activities

Constitutes different activities, the most important of which are:

- Trade, especially in the urban regions and village markets.
- Agricultural labor, especially in sugar schemes, the White Nile agricultural schemes, Gaziera scheme and most of it comes from the

Southern and Western States and the rural areas of the State, especially in summer.

- Firewood and charcoal trading, especially in Rawat locality.
- Trading in drinking water, especially in outskirt quarters of the towns and in the rural areas in summer.
- Fishing and fishing industries along the White Nile for local consumption and exporting to the national capital.
- Small rural industries like cheese industry in Kosti and Edduweim provinces.

4.4 Poverty

Poverty is spread among many State localities and most of its indicators are the following:

- Poor housing and the spread of the random extensions, the low personal incomes and the population instability as a result of the shortage and lack of drinking water in the remote areas from the White Nile river, the spread of malnutrition diseases specially in Guli and Um Remta localities, and the high rates of school dropouts when students desert their schools to assist their relatives in fetching water or in animal pasture, the migration of poor families searching for water and work opportunities specially in summer season and the deterioration of health and school services beyond the White Nile belt.
- Deterioration of the situation during the persisting drought (specially during the eighties) and its results of animal loss, the deterioration of pasture and the failure of agriculture, specially in Tadamon, Um Remta, Tandalti and Sheikh Sidig localities. There are also the

devastating floods in Tandalti and Gazeira Aba localities and the break down of most of the White Nile irrigated schemes.

4.5 Environmental Hazards:

The environmental and health hazards are found in the following:

- Consecutive drought intervals and its repercussion of pasture deterioration, loss of animal wealth, deterioration of soil, and shortage of drinking water.
- Desertification and its results, which is represented in population and their incomes instability, desert displacement which covers agricultural lands, valley's runways and hafirs.
- Deterioration of environmental sanitation in the unplanned extensions areas and refugees camps in Kosti, Rabak, Asalaya, Kennana towns and the spread of epidemic diseases.
- Factories industrial waste especially in Kennana and Asalaya localities.
- Repeated floods, loss of houses, crops and properties.
- Spread of the White Nile waterweeds and its hindrance to river navigation and deterioration of fish environment.

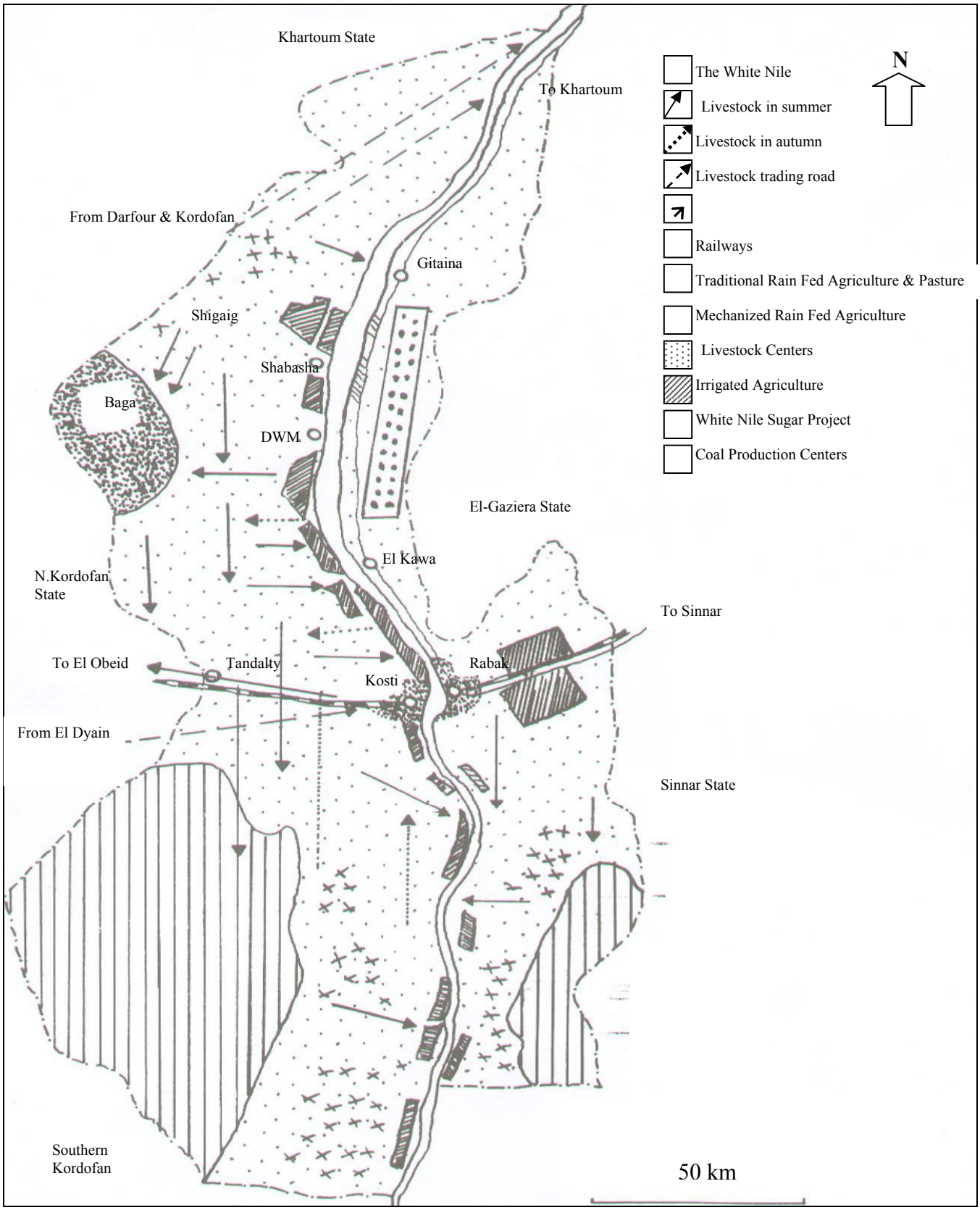

Figure (4.2): Land uses map

4.6 Water Resources [6]

The fact that the State is located in the dry region makes water resources an expensive commodity composed of rain water, seasonal valleys, the White Nile River and the groundwater (figure 4.5).

4.6.1 Rainfall Water

Though rain water rates are deteriorated and its high fluctuation and the short period of rainy season, it is still considered one important source, especially in Savanna belt, and the rain-fed agriculture, pasture, forest resources and drinking water especially for animal depend upon it

Rainfall rates vary on the long run between less than 200 mm/year in the North and more than 500 mm/year in the South. It is much affected by the short drought intervals as well as by high evaporation rates.

By using rainfall rates which is 370 mm/year in Kosti, 240 mm/year in Edduweim (Figure (4.3), (4.4)) and the State area which is 31,000 square kilometers, the annual total rainfall can be estimated to be around 9 billion cubic meters.

4.6.2 Seasonal Wadis

The evaporation rates which are higher than rainfall rates even during autumn create a large water gap. But the rainfall rate that exceeds 20 mm/day can cause water runoff.

In the northern regions, where there is the sandy soil, the bulk of rain precipitation infiltrates into the ground which helps in matching the requirements of the rain-fed cultivation and vegetation cover and supplies the groundwater which is near to the surface, and it is re-evaporated.

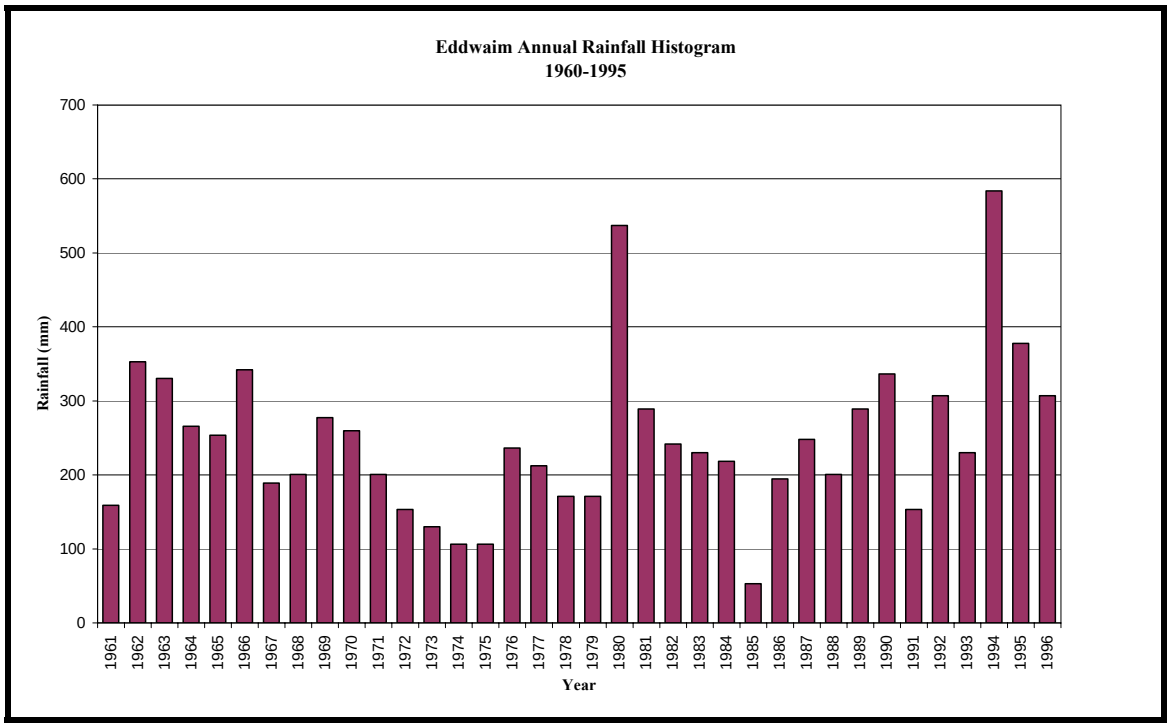

Figure (4.3): Edduweim rainfall histogram

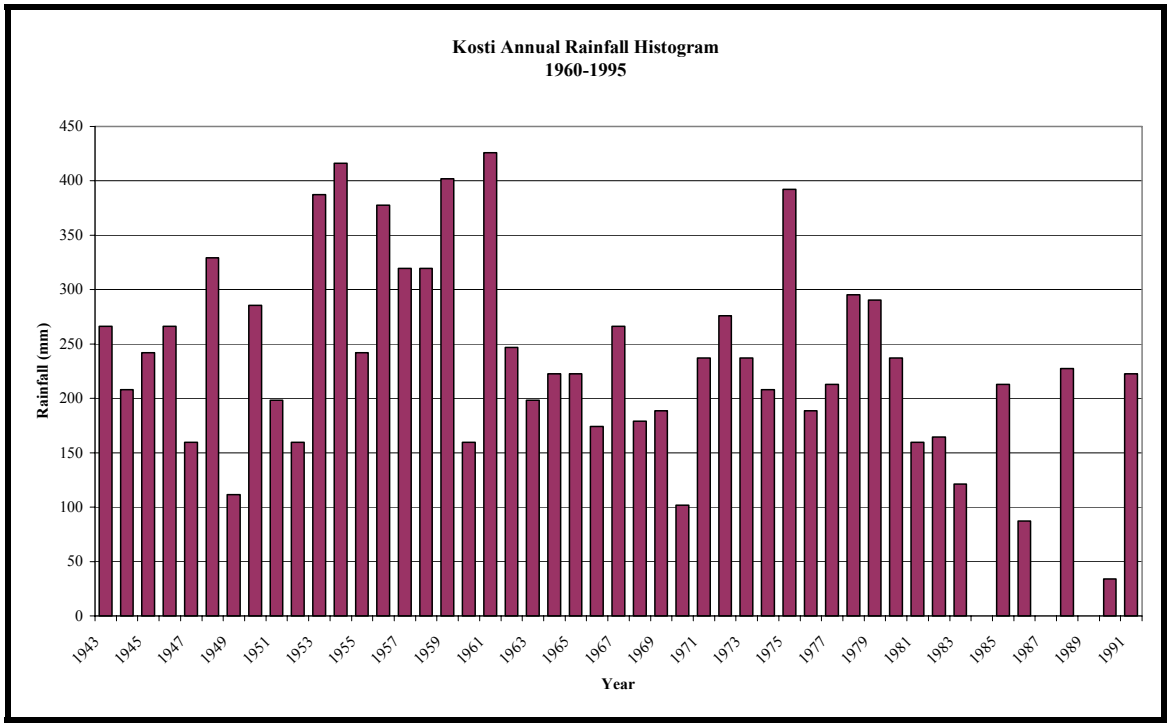

Figure (4.4): Kosti rainfall histogram

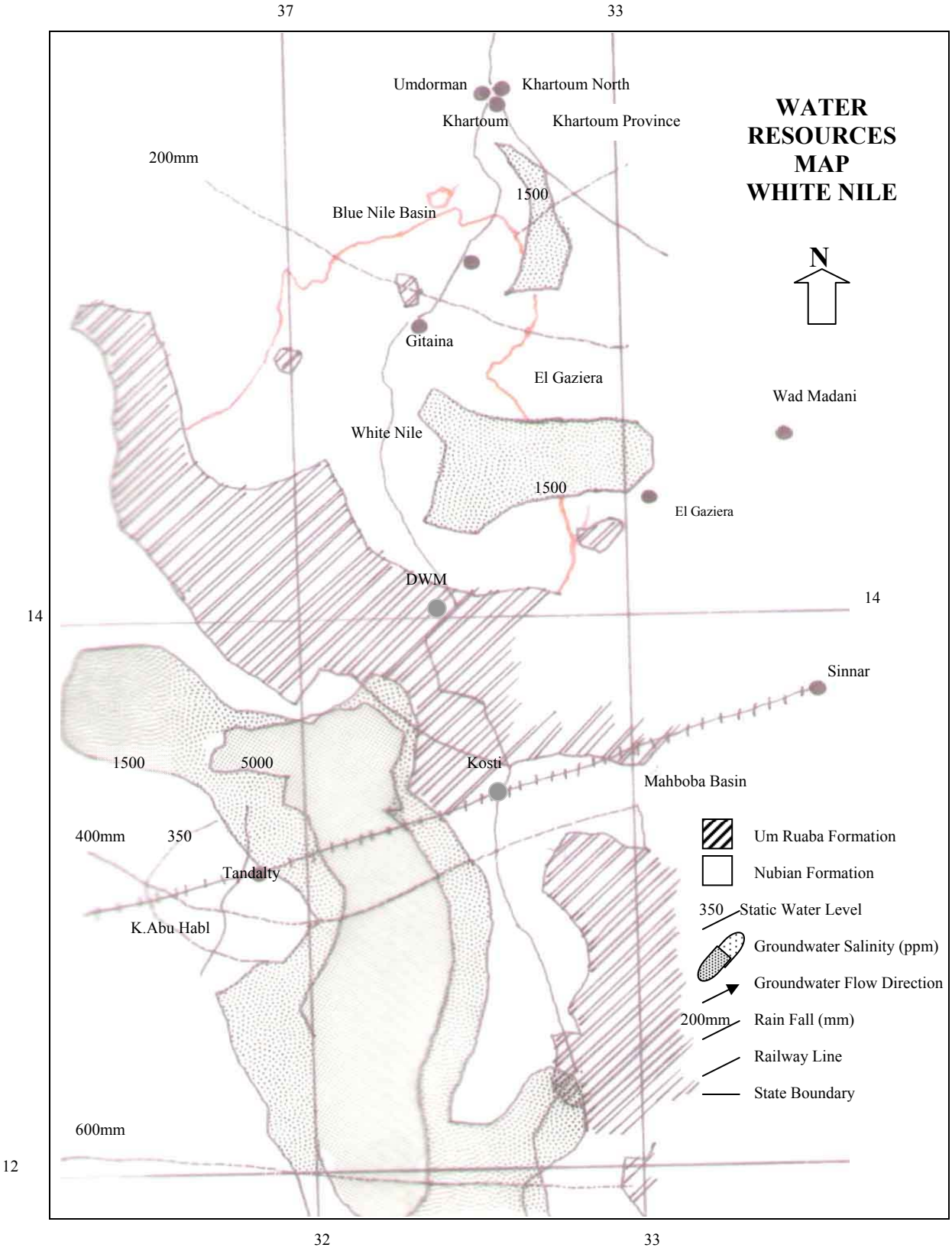

Figure (4.5): Water resources distribution

Runoff coefficient in the Northern regions is estimated to be around 0.2% of the rainfall rates. It is formed in a sheet flow upon the sand dunes and then discharge into natural depressions and then fills Hafirs. Runoff volume is estimated in the Northern area which covers 60% of the area in the State by around 90 million m^3/year.

Khor Mutrag, Arashkol, Um Remta and Efaitis are the most important streams in the Northern region. Water surfaces in Halba, Wad Jabor and Um Remta are the most important seasonal water resources. Water basins along Abu Habl delta are important water source for animal to drink in Autumn and for the wells centers (Idd).

The Southern region which covers 40% of the State area is characterized by a flat clayey surface and a reasonable vegetation cover and a rainfall rate of 370 mm. runoff coefficient here is estimated to be 3% causing a runoff estimated to be 140 million m^3/year.

The topographic steepness and the location of the region within the White Nile basin, the Wadis run towards the White Nile. Abu Habl is the most important Seasonal Wadi which flows from the mountainous heights of Northern and Southern Kordofan passing by Tendalti town and branching into a delta. It inflows into the White Nile in the rainy years through Rawat locality in the dry years ending up into water pools or to be infiltrated into the sand dunes. The pools retain their water to a period of one month prior to the rainy season.

The flow rate of Khor Abu Habl at Alsimaih varies between 40 to 126 million cubic meters in a season where the maximum flow reaches 162 m^3/s.

4.6.3 The White Nile River

The White Nile is considered the main source for surface water and it passes the State from South to North. The White Nile is characterized by having a wide and shallow channel, the gradual change in the water levels, the chemical mixture (less than 150 units per million), low levels of turbidity and the increase in the suspended matters which necessitates purifying all through the year. These suspended matters hinder sterilization process necessary for the human use.

The chemical survey results made by the National Water Authority during the year 1998 shows some contamination in the White Nile water such as low rates of oxygen in the water (2.5 unit per million) and the high rate of oxygen required for biochemical operations (BOD 252 ppm), (Table 4.6).

Table (4.6): The White Nile Water Quality (1998)

Area	*Temperature (c)*	*Conductivity (Us/cm)*	*Alkalinity (PH)*	*Turbidity (FTU)*	*Suspended Solids (PPM)*	*Dissolved Oxygen (Mg/L)*	*BOD (Mg/L)*
Kosti bridge	29.5	170	7.2	47	26	2.5	252
Oil milling factory	29.8	190	7.4	109	110	4.2	162
Jabal Awliaa	27.8	200	8.0	39	47	6	243
Elshagara	27.0	210	8.0	79	73	5	100

Reference: National Water Corporation (1998).

Bacteriological analysis conducted by the Federal Ministry of Health and the National Water Corporation in the State in the year 1999 show that the White Nile water is contaminated by the human waste bacteria during the first period of the flood causing wide waves of diarrhea and probably cholera. This is resulting from the White Nile water contamination by

agricultural fertilizers waste, waterweeds and its pesticides and industrial waste. This requires the protection of the White Nile water from the danger of contamination.

The White Nile flow measured in Malakal town ranges between 525 m^3/s and 1215 m^3/s. during the period (1911-1962). Its annual flow is between 13 and 23 billion cubic meters and it's considered a continuous source for agricultural, human and animal drinking purposes.

4.6.4 The Groundwater:

The groundwater, under the prevailing threatening drought, is considered the most important source for drinking water especially for those remote areas from the White Nile. It is also characterized by its direct use for drinking without need for expensive and complicated treatments and sterilization processes.

The groundwater is available by different qualities below more than 60% of the State area in the Nubian rocks, Um Rawaba rocks and in the alluvial deposits along the White Nile and in different areas in the large seasonal valley runways and in wide natural depressions (Mayaat) areas among the sand dunes.

The groundwater is intensively found in the Nubian rocks in the Blue Nile groundwater aquifer in Gitaina province and in great parts of Shabasha and Um Remta localities in DWM province. The quality of its water is good and its saltiness increases at parts of Shaikh Sidig locality. The groundwater flow from the Blue Nile groundwater aquifer and the leakage from the White Nile water are the main sources of continuous supply for the basin.

The White Nile groundwater aquifer extends through the Western and Southern parts of the State and constituted from the thick Um Rawaba rocks

and mostly contains high salty water (> 300 unit/million) with the increase of the concentration of Sulphate and Chloride, which makes it unsuitable for human consumption.

The Western side of the aquifer, through Tendalti locality, gets water from the infiltrated water from Khor Abu Habl where the salt and other materials are at low density. So water is suitable for human consumption. The availability of the groundwater at the depth of more than 50 meters and the accumulation of the soft sands are considered the main obstacles to the utilization of the groundwater. Mahboba ground aquifer which links between the White and Blue Nile basins extends from East to West, South to Rabak town and its composed of the Nubian rocks and the thick Paleozoic rocks and it contains groundwater which supposed to be a rich one. Studies and digging results showed that there is potable water available in the Eastern area of the aquifer, in the North of Dali and Jafarat in Sennar State.

There is also the experimental digging in Rabak which revealed the existence of a groundwater reservoir with diversified types of water ranging between salty and potable. The basin needs more hydro-geophysical studies.

The groundwater are found in the alluvial deposits along Abu Habil Khor and also subsurface water is observed below some natural depressions at a depth ranging between 2-6 meters depending on the supply sources, pumping rates and topography. It is intensively utilized by Idd and it is susceptible to bacterial contamination as a result of exploitation technology and the continuous availability of animals around it. The places of Um Remta, Halba, Wad Gabor and large parts of Guli and Rawat localities are considered the most important places of Idd.

The presence of clayey layer along the White Nile runway hinders its water leakage to supply precipitation reservoirs around it, which mostly contains groundwater with high salt density.

4.7 Drinking Water Needs (1999)

The human and animal needs for drinking water are estimated according to the following bases:

- The 1999 population for human and animal in the State.
- Estimates of WHO and Federal Ministry of Health for the actual needs of the rural people, which reach 20 l/c/d as a minimum requirement and increases with the increase in the rate of settlement.
- Level of urbanization and the need for drinking water, sanitation, domestic house requirements and for irrigating house gardens. The current consumption of water ranges between 50-80 l/c/d in the urban regions.
- The needs of semi urban areas and the expected development (30-60 l/c/d).
- The biological need of animal, which is (25 liters/head/day) for cattle, (10 l/h/d) for sheep and goat and (12 l/c/d) for camels. The tables (4.7), (4.8) and (4.9) show the needs for water in 1999 for the State population in the rural, urban and semi urban regions as follows:

Table (4.7): The need of water in rural areas (1999)

Province	*Locality*	*Daily needs (m^3)*
		1999
		20 L/C/day
Kosti	Tandalty	2,371
	Guli	2,433
	Um Hani	253
	Naeim	477
	Rawat	888
	Total	**6,422**
DWM	Shabasha	1,375
	Tadamon	1,150
	Um Remta	881
	Wohda	1,161
	Total	**4,567**
Gitaina	Shaikh Sidig	602
	Elkawa	1,337
	Gitaina	2,084
	Total	**4,023**
Jabalain	Gazeira Aba	826
	Asalaya	623
	Kennana	1,184
	Jabalain	812
	Total	**3,445**
Total		**18,457**

Table (4.8): The need of water in semi urban areas (1999)

Province	*Locality*	*Daily needs (m^3)*
		1999
		20 L/C/day
Kosti	Guli	242
	Rawat	171
	Naeim	53
	Um Hani	231
	Total	**697**
DWM	Shabasha	361
	Ziraiga	38
	Wad Nimir	300
	Um Jar	156
	Total	**855**
Gitaina	Shaikh Sidig	**51**
Jabalain	Asalaya	253
	Jabalain	230
	Total	**383**
Total		**2,086**

Table (4.9): The need of water in urban areas (1999)

Province	*Town*	*1999*	
		L/C/day	**m^3/day**
Kosti	Kosti	80	19,799
	Tandalty	60	3,480
	Total		**23,279**
DWM	**DWM**	**70**	**4,610**
Gitaina	Elkawa	60	322
	Gitaina	80	1,290
	Total		**1,612**
Jabalain	Gazeira Aba	50	1,172
	Kennana	80	1,208
	Rabak	80	5,477
	Total	**80**	**7,857**
Total			**37,358**

Table (4.10): The total need of water for rural and urban areas (1999)

Province	*Town*	*1999*
Kosti	Rural	23,279
	Semi-urban	697
	Urban	6,422
	Total	**30,398**
DWM	Rural	4,610
	Semi-urban	855
	Urban	4,567
	Total	**10,032**
Gitaina	Rural	1,612
	Semi-urban	51
	Urban	4,023
	Total	**5,686**
Jabalain	Rural	7,857
	Semi-urban	483
	Urban	3,445
	Total	**11,785**
Total		**57,901**

Table (4.11): The Animal need of water in m^3/day (1999)

Province	*Year*
	1999
Kosti	58,246
DWM	27,905
Gitaina	4,442
Jabalain	29,255
Total	**119,848**

Table (4.12): The State total drinking water needs for human and animal consumption (1999)

Province	*Town*	*1999*
Kosti	Human need	30,398
	Animal need	58,246
	Total	**88,644**
DWM	Human need	10,032
	Animal need	27,905
	Total	**37,937**
Gitaina	Human need	5,686
	Animal need	4,442
	Total	**10,128**
Jabalain	Human need	11,785
	Animal need	29,255
	Total	**41,040**
Total		**177,749**

4.8 Sanitation Services Needs [6]

Sanitation sector in Sudan is characterized by scarcity of information and statistics. This ascribed to the fact that it is an activity undertaken by individuals; there is no national institution that supervises it. It is also ascribed to the low ranking of the sector by the governments and societies.

The linking of water services with sanitation services in Sudan, till recently, was considered a donors policy introduced by Water and Sanitation project (WES) supported by UNICEF and was adopted by some NGOs before being accepted by National Water Corporation as a national policy.

Lessons learned from the Blue Nile Health Project studies was that the health effect from providing healthy water only is a preliminary and temporary, for healthy water in the absence of sanitation bodies and the deterioration of health awareness is expected to be easily contaminated during transportation, storage and usage processes.

The size of the required sanitation facilities can be estimated in the light of population statistics and the family size which is 6.15, 6.1 and 6 persons in the rural, semi-urban and urban areas, respectively, and that's according to the population census carried by the White Nile State (1993).

Tables No. (4.13), (4.14) and (4.15) show the number of house sanitation facilities in rural, semi-urban and urban areas of the State for the year 1999.

Table (4.13): The number of home latrines in rural areas

Province	***# Of home latrines available***
	1999
Kosti	52,000
DWM	37,000
Gitaina	33,000
Jabalain	29,000
Total	151,000

Table (4.14): The number of home latrines in semi urban areas

Province	***Locality***	***1999***
Kosti	Guli	1,320
	Rawat	950
	Naeim	290
	Um Hani	1,260
	Total	**3,800**
DWM	Shabasha	1,970
	Ziraiga	210
	Wad Nimir	1,640
	Um Jar	850
	Total	**4,660**
Gitaina	**Shaikh Sidig**	**280**
Jabalain	Asalaya	1,380
	Jabalain	1,260
	Total	**2,640**
Total		**11,390**

Table (4.15): The number of home latrines in urban areas

Province	*Town*	*1999*
Kosti	Kosti	41,660
	Tandalty	9,670
	Total	**51,330**
DWM	**DWM**	**10,980**
Gitaina	Gitaina	2,690
	Elkawa	890
	Total	**3,580**
Jabalain	Gazeira Aba	3,910
	Rabak	11,410
	Kennana	2,520
	Total	**17,840**
Total		**83,730**

4.9 Water & Sanitation Services Situation [6]

4.9.1 Drinking water:

It is composed of traditional sources of natural depression (Birak,Rohood), shallow wells and Idd wells which were located beside the White Nile water. And the improved sources which include treatment stations for the White Nile water, slow sand filters on the irrigated canals, hafirs, dams and pumps. Rainfall, Wadis, the White Nile and the groundwater are exploited to provide the rural and urban needs for water

4.9.1.1 Rural Water Sources:

Rain Hafirs, Nile Hafirs and Canal Hafirs represents the most important sources for surface water in the State. There are 95 rainwater Hafirs with a design capacity of about 1,356,000 m^3 most of them are concentrated in southern clayey regions. There are also three soil dams in each of Rawat, Halba and Wad Gabor with a total capacity of 600,000 m^3. It provides

human and animal with continuous drinking water or most of the year. Road pits (its number is estimated to be about 32) along the highway (Obied-Kosti) with a storage capacity of 1.6 million $m^3$of water. It is the most important source of water for local and commercial animals during the period (July-January).

There are 24 Nile Hafirs with a capacity of 384,000 m^3. Which are fed from the Nile during flood season or from the irrigation canals, most of them are in Edduweim province. There are 15 Nile projects most of which are in Jabalain province. Slow sand filters are supplemented to them to provide drinking water for humans, especially in Assalaya Sugar Project. But lack of maintenance made it currently just to provide non processed raw water.

Due to the fact that Hafirs and dams, their proposed lifetime has expired beside the absence of maintenance and with the deterioration of rainfalls, The current using capacity is 50% of the designed capacity. The useful storage is around 15% and 50% for Nile Hafirs and 60% for canal Hafirs which are filled twice a year. Hafirs and dams water are susceptible to evaporation and pollution, it is generally not suitable for human use.

Table No. (4.16) show the surface sources, their diffusion, their capacities and their average water quantities per one day and for the whole year, considering that Hafirs water is not available for more than 3 to 6 months after the end of the autumn season.

Groundwater wells, Hand pumps, traditional wells and (Idd) wells are the groundwater sources in the State. There are 287 groundwater wells which forms 258 water stations, 54% of them are in Gitaina province, 28% in Kosti province (Tendalti Locality), 27% in Edduweim province.

Out of 287 wells, only 207 are operating. The rest are abandoned, either because of saltiness or the ending of its proposed lifetime which goes back

to the anti-thirsty campaign (1969-1975). The reciprocation pumps mostly in Tendalti Locality, produces around 4 m^3/hour whereas the vertical turbine pump produces 20 m^3/hour. And by assuming that the average is 10 operational hours per day for the reciprocation pumps and 5 hours per day for the turbine pumps, the groundwater wells are producing the total of around 16.916 m^3/day of hygienic water.

The deep wells were introduced and hand pumps were installed recently, 190 wells were dug, out of which 156 pumps are operating in 96 villages and produces 2,340 m^3/day and the rest are abandoned because of the increase of salt in the groundwater.

There is a large number of shallow wells in the State distributed in 179 villages and produce 6,726 m^3/day, and concentrated in Gitaina province (82.7%). The rest are distributed between Edduweim provinces (13.4%) Kosti (3.4%), Jabalain (0.6%). There are also 123 group of traditional wells (Idd) in the State which produce 5,193 cubic meters daily, 76.4% in Kosti province (Guli Locality) and 23.6% in Edduweim province. Shallow wells are used for human drinking whereas traditional wells (Idd) water is for animals drinking. The water of both sources is susceptible to bacterial pollution and do not provide healthy water (table 4.17).

Table (4.16): The State Surface Water Resources and its Production Capacity

Province	Locality	Rain Water Hafirs		Nile Hafirs/Canal		Nile Projects		Sand Dams		The road holes		Surface Water Available Quantities m^3/day
		No #	Design Volume m^3	No #	Design Volume m^3	No #	Design Volume m^3	No #	Design Volume m^3	No #	Design Volume m^3	
Kosti	Tandalti	20	17,770	-	-	-	-	-	-	8	400,000	289
	Rawat	15	400,000	-	-	-	-	2	200,000	-	-	300
	Um Hani	2	10,000	3	75,000	-	-	-	-	-	-	130
	Naiem	-	-	1	20,000	-	-	-	-	-	-	40
	Guli	21	268,000	2	45,000	1	28	-	-	24	1,200,000	1,452
	Total	**58**	**85,700**	**6**	**140,000**	**1**	**28**	**2**	**200,000**	**32**	**1,600,000**	**2,211**
DWM	Shabasha	6	140,000	2	42,000	1	80	2	400,000	-	-	634
	Tadamon	2	22,000	7	102,000	-	-	-	-	-	-	181
	Wohda	5	24,000	1	15,000	-	-	-	-	-	-	57
	Um Remta	3	65,000	1	15,000	1	50	-	-	-	-	113
	Total	**16**	**281,000**	**11**	**174,000**	**2**	**130**	**-**	**-**	**-**	**-**	**985**
Gitaina	Gitaina	-	-	-	-	-	-	-	-	-	-	0
	Elkawa	-	-	-	-	1	40	-	-	-	-	40
	Sheikh Sidig	-	-	-	-	-	-	-	-	-	-	0
	Total	**-**	**-**	**-**	**-**	**1**	**40**	**-**	**-**	**-**	**-**	**40**
Jabalain	Gaziera Aba	4	25,000	4	40,000	-	-	-	-	-	-	93
	Assalaya	1	15,000	-	-	9	96	-	-	-	-	104
	Kennana	8	85,000	2	20,000	1	30	-	-	-	-	113
	Jabalain	8	95,000	1	10,000	1	30	-	-	-	-	96
	Total	**21**	**220,000**	**7**	**70,000**	**11**	**156**	**-**	**-**	**-**	**-**	**409**
Total		**95**	**1,356,000**	**24**	**384,000**	**15**	**354**	**4**	**600,000**	**32**	**1,600,000**	**3,642**

Table (4.17): Underground Water Resources and its Production Capacity in the State.

Province	*Locality*	*Groundwater Wells*		*Hand Pumps*		*Shallow Wells*		*Idd Wells*		*Quantities available*
		No #	**m^3/day**	**No #**	**m^3/day**	**No #**	**m^3/day**	**No #**	**m^3/day**	***m^3/day***
Kosti	Tandalti	34	2,450	-	-	4	47	15	75	2,572
	Rawat	-	-	13	195	-	-	12	853	1,048
	Um Hani	3	148	3	45	-	-	3	150	343
	Naeim	-	-	2	30	1	15	4	200	245
	Guli	1	40	1	15	1	90	60	1,800	1,945
	Total	**38**	**2,638**	**19**	**285**	**6**	**152**	**94**	**3,753**	**6,828**
DWM	Shabasha	12	1,200	18	270	11	1,216	9	780	3,466
	Tadamon	12	1,200	12	180	9	230	5	150	1,760
	Wohda	3	150	3	45	1	15	12	360	570
	Um Remta	23	1,750	2	30	3	130	3	150	2,235
	Total	**50**	**4,275**	**35**	**525**	**24**	**1,591**	**29**	**1,440**	**7,831**
Gitaina	Gitaina	68	5,740	37	555	81	2,567	-	-	14,602
	Kawa	36	2,848	40	600	48	1,616	-	-	7,912
	Sheikh Sidig	13	1,095	19	285	19	760	-	-	3,235
	Total	**117**	**9,683**	**96**	**1,440**	**148**	**4,943**	**-**	**-**	**25,749**
Jabalain	Gazeira Aba	2	320	-	-	1	40	-	-	360
	Asalaya	-	-	-	-	-	-	-	-	-
	Kennana	-	-	-	-	-	-	-	-	-
	Jabalain	-	-	6	90	-	-	-	-	90
	Total	**2**	**320**	**6**	**90**	**1**	**40**	**-**	**-**	**450**
Total		**207**	**16,916**	**156**	**2,340**	**179**	**6,726**	**123**	**5,193**	**31,170**
Ratio %			**54.2**		**7.5**		**21.6**		**16.7**	**100**

From the table (4.17) it is clear that the groundwater wells are the main source for the groundwater, followed by shallow wells water then traditional wells (Idd). The traditional sources which are developed by communities and represented in the shallow wells and traditional wells (Idd) provide about 38.3% of the groundwater available in the State.

Traditional (Idd) wells are the main source for the groundwater in Guli, Rawat and Naeim localities. Therefore, the total water provided in the rural areas is 34,817 m^3/day; their distribution is shown in table (4.18).

The table shows that the groundwater shares by about 89.5% of total available rural water whereas surface water sources, excluding the White Nile, have a share of 10.5% only. The distribution of surface water does not reflect real picture. It is available in abundance during rainy seasons and a little bit after. It becomes dry during summer.

4.9.1.2 Rural Water Services Situation:

The baseline survey, done by the Water and Sanitation project (WES) in the White Nile State (1999), provided information at the village level about the drinking water consumption rates, types and capacities of sources and also the co-average (table 4.19) shows the following:

- The average individual consumption of water is 16.2 liters/day which equals 81% of the minimum required rate, due to the WHO statistics. Gitaina has the highest rate which is 18.4 l/c/d. Assalaya locality is also has a high rate. But Kosti localities have the lowest rate of 13.9 % liters. This reflects the situation of water sources.

- The groundwater wells and hand pumps provide healthy water of about 19,256 m^3/day that is the rate of 55% of the rural water. The average individual consumption then becomes 8.9 liters/day compared to the actual need which is 20 liters as a minimum.

Table (4.18): The Water Quantities Available in the Rural Areas

Province	*Locality*	*Underground Water m^3/day*	*Surface Water m^3/day*	*Total Quantities m^3/day*
Kosti	Tandalti	3,247	289	3,536
	Rawat	1,048	300	1,348
	Um Hani	343	130	473
	Naeim	245	40	285
	Guli	1,945	1,452	3,397
	Total	**6,828**	**2,211**	**9,039**
DWM	Shabasha	3,466	634	4,100
	Tadamon	1,760	181	1,941
	Wohda	570	57	627
	Um Remta	2,035	113	2,148
	Total	**7,831**	**985**	**8,817**
Gitaina	Gitaina	8,862	0	8,862
	Kawa	5,064	40	5,140
	Sheikh Sidig	2,140	0	2,140
	Total	**16,066**	**40**	**16,106**
Jabalain	Gazeira Aba	360	93	453
	Asalaya	0	104	104
	Kennana	0	113	113
	Jabalain	90	96	186
	Total	**450**	**406**	**858**
Total		**31,165**	**3,642**	**34,817**
Ratio %		**89.5**	**10.5**	**100**

Table (4.19): The Rural Water Services Situation (1999)

Province	Locality	Total quantities available m^3/day	Human needs m^3/day (20 L/c)	Human current consumption m^3/day	Avail. quantity for one person L/day	Water Quality	Animal needs m^3/day	Animal consumption m^3/day	Remarks
Kosti	Tandalti	3,536	2,371	1,622	13,7	Healthy		1,914	Animal cons. 54% of avail. water
	Rawat	1,348	888	606	13,6	Not Healthy		742	Animal cons. 55% of avail. water
	Um Hani	473	253	185	14,6	Not Healthy		288	Animal cons. 61% of avail. water, and get other needs from the Nile
	Naiem	285	477	361	15,1	Not Healthy			Human cons. 21.1% of the Nile, the whole animal needs from the Nile
	Guli	3,391	2,433	1,780	14,6	Not Healthy		1,611	Animal cons. 47.6% of available water, other needs from the Nile
	Total	**9,039**	**6,422**	**4,554**	**13,9**		**58,246**	**4,561**	Avail. resources cover 69.5% of human cons. And 7.8% of animal cons.
DWM	Shabasha	4,100	1,375	1,002	14,6	Healthy		3,098	Animal cons 75.6% of avail. water
	Tadamon	1,941	1,150	1,029	17,6	Not Healthy		912	Animal cons. 47% of avail. water
	Wohda	627	1,156	949	16,4	Not Healthy			66.1% of human needs depend on avail. sources, the Nile cover other needs of human and animal
	Um Remta	2,148	881	726	16,5	Healthy		1,422	Animal cons. 66.2% of avail. water
	Total	**8,816**	**4,562**	**3,706**	**16,2**		**27,905**	**5,432**	Animal cons. 19.5% and human cons. 81.2%
Gitaina	Gitaina	8,862	2,084	2,092	20	Healthy		6,770	Animal cons. 76.4% of avail. water
	Elkawa	5,104	1,331	1,101	16,5	Healthy		4,003	Animal cons. 78.4% of avail. water
	Sheikh Sidig	2,140	602	505	16,5	Healthy		1,635	Animal cons. 76.4% of avail. water
	Total	**16,106**	**4,023**	**3,698**	**18,2**		**119,848**	**12,408**	Cons. Is 7,966 cm/day either by animals from out of the province or because of broken Donkys
Jabalain	Gaziera Aba	453	826	723	17,5	Not Healthy			Canals/White Nile covers 37.3% of human needs and all animal needs
	Assalaya	104	623	566	18,2	Not Healthy			Canals/White Nile covers 81.6% of human needs and all animal needs
	Kennana	113	1,184	1,022	17,3	Not Healthy			Canals/White Nile covers 88.9% of human needs and all animal needs
	Jabalain	186	812	675	16,6	Not Healthy			Canals/White Nile covers 72.4% of human needs and all animal needs
	Total	**856**	**3,445**	**2,986**	**17,3**		**29,255**		Current sources cover 28.7% of human needs and all animal needs
Total		**34,817**	**18,452**	**14,944**	**16,2**		**119,848**	**22,401**	Current sources cover 81% of human needs and 18.7% of animal needs

- Traditional sources and Hafirs which mostly do not provide healthy water are the main sources of water in Kosti province and a large part of Edduweim and Jabalain provinces, whereas the province of Gitaina, Tendalti, localities, Um Remta locality and part of Shabasha locality enjoy healthy groundwater. This requires improving the quality of water as a priority in the near future.
- The total rural human water consumption is 14,944 m^3/day which equal 43.7% of the daily available water. Animals consume 67.2% of the available water. This means to put the animals water needs into consideration during the planning for the rural water services.
- All types of the current sources provide 81% of the human needs and 27% of animal needs. The shortage is covered by (demand pressure) for the human, and from the White Nile water and irrigation canals for animals. Gitaina province water sources provide a considerable amount of the needs of animals coming from outside the State.

4.9.1.3 Semi-Urban Water Supply:

- Table (4.20) shows types of sources and the drinking water supply situation in the semi-urban areas.

- Semi-urban areas are mostly composed of villages which were recently upgraded to centers for new localities. These are expected to rapidly grow at a pace that exceeds the rural population growth.

- Average individual consumption in semi-urban areas is 15.7 liters/day, 7.9 liters out of it is considered healthy water.

- Gitaina and Jabalain provinces towns enjoy the best water services from the side of quantities. It reaches 18.4 liters and 17.3 liters in the two provinces respectively. It reaches its minimum in Kosti province towns which is 12.7 liters only.

- Excluding Shabasha and Wad Nimir localities in Edduweim province and Shiekh Sidig in Gitaina province, the semi-urban areas depend on the Nile water and Hafirs which is mostly not healthy water. This requires giving the semi-urban areas special consideration when planning for water services provision.

Table (4.20): The Semi-Urban Drinking Water Situation (1999)

Province	***Town***	***Daily Needs***		***Quantities Available***		***Additional water needed m^3/day***	***Water Quality***
		m^3/day	***L/person***	***m^3/day***	***L/person***		
Kosti	***Guli***	242	30	89	11	153	Not Healthy
	Rawat	172	30	78	13.7	93	Not Healthy
	Naeim	53	30	24	13.6	29	Not Healthy
	Um Hani	231	30	105	13.6	126	Not Healthy
	Total	**697**		**296**	**12.7**	**401**	
DWM	***Shabasha***	361	30	209	17.4	152	Healthy
	Ziraiga	45	30	27	18	18	Not Healthy
	Wed Nimir	300	30	182	18.2	118	Healthy
	Um Jer	156	30	95	18.3	61	Not Healthy
	Total	**8,620**		**513**	**17.9**	**349**	
Gitaina	***Sheikh Sidig***	51	30	31	18.2	20	Acceptable
Jabalain	***assalaya***	253	30	153	18.1	100	Healthy
	Jabalain	230	30	105	13.7	125	Not Healthy
	Total	**483**		**285**	**16**	**225**	
Total		**2,093**		**1,098**	**15.7**	**1,000**	

4.9.1.4 Urban Water Sources:

Urban water sources are composed of Nile Stations, Canals and the groundwater Wells.

The Nile Water Sources are water treatment stations composed of the intake, pipes to carry raw water, treatment station which composed of sedimentation basin, rapid sand filters, chlorine apparatus for sterilization, treated water basin, elevated water tanks, pumping and distribution network, houses connections and public water taps. Kenana treatment station is composed of slow sand filters a producing capacity of 4,500 m^3/day. Sterilizing apparatus, high storage tanks and a distribution network which covers the town by a 100%, the water supply enjoys a capable administration and financial abilities not available elsewhere.

Tandalti, Gitaina and Elkawa towns depend on the groundwater wells upon which electrical pumps are installed, elevated tanks and distribution networks for houses and public water taps and it's used without sterilization (Table 4.21).

- Individual consumption rate for water in urban centers ranges between 12.7 liters/day in Gazeira Aba and 105 liters/day in Kenana town and in the average it is 45.3 liters/day which equals to 60% of the actual needs (Table 4.21).
- The highest daily consumption rates is 105 liters/day in Kenana does not reflect the reality, for most of water is consumed in irrigating house gardens.
- Gitaina water source, which are wells and pumps are enough for the current and future town's need till the year 2015 and it lacks the distribution network.

- Gazeira Aba town is endowed with water resources but suffers from the low health awareness, where the daily water consumption rate is very low and the people depend on the Nile Water and irrigation canals though there are houses connections.
- Excluding Kenana, houses connections ratio is very low, it reaches 5% only in Tandalti, 15% in Kosti and 68% in Gazeira Aba as the highest rate can be compared to Khartoum situation.
- 95% of Tendalti population depends on the public water taps and mobile water.
- Those that depend on traditional and unhealthy sources range between 7% in Gazeira Aba and 35% in Kosti town.
- The fact that there is a lack of treatment materials and analysis laboratories made the Nile towns depends on the raw water. This needs consideration in the future.

4.9.1.5 The State Water Services Improvement Obstacles:

Drinking water Services improvement in the State to meet the current and future needs faces many problems including the financial problems, water resources and sources, technical, administrational , social and environmental problems.

Table (4.21): The Urban Areas Water Services Situation (1999)

Province	*Town*	*Daily Needs*		*Quantities Available*	*Human Consumption*	*Type of Service %*			*Dependency Degree*	*Water Quality*
		M^3/day	*L/day*	*m^3/day*	*L/day*	*Home connections*	*Public Taps*	*Traditional Sources*		
Kosti	***Kosti***	19,799	80	12,320	49.8	15	50	35	Low	accepted
	Tandalti	3,480	60	907	15.6	5	95	-	Low	accepted
	Total	**23,279**		**13,226**	**43.3**					
DWM	***DWM***	4,610	70	3,024	45.9	41	29	30	Moderate	accepted
Gitaina	***Gitaina***	1,291	80	910	56.4	45	40	15	Moderate	Healthy
	Elkawa	322	60	111	20.7	53	32	15	Moderate	Healthy
	Total	**1,613**		**1,021**	**47.5**					
Jabalain	***Gazeira Aba***	1,172	50	298	12.7	68	25	7	Moderate	accepted
	Kennana	1,209	80	1,587	105	100	-	-	High	Healthy
	Rabak	5,447	80	3,500	51.1	34	40	26	Moderate	accepted
	Total	**7,858**		**5,385**						
Total		**41,970**		**22,657**	**45.3**					

4.9.1.5.1 Water Resources:

- Low rates of rainfall in the Northern areas, there is also its irregularity, high rate of evaporation and the sandy soil where runoff rate is reduced to 0.2%.
- High rates of sedimentation in the Seasonal Wadis waters as a result of erosion in the upstream, beside the high evaporation and the lack of Wadi's discharge measurements.
- High rates of salinity in the groundwater in the White Nile aquifers and the great depth of groundwater which multiplies pumping cost especially in Tandalti locality.
- The nature of salty groundwater causes the erosion of the water tanks, pumps and the pipe lines in Tandalti areas and parts of Edduweim and Gitaina provinces.
- Lack of hydro geophysical studies which resulted into the lack of knowledge about the groundwater availability places and their types in many areas.
- High ratio of suspending materials in the White Nile waters all the year round which raises the cost of treatment and hinders sterilization processes.
- The low Level of the White Nile River in summer and the remoteness of water from the intake.

4.9.1.5.2 Water Sources:

- Hafirs with small storage capacities is susceptible to evaporation and infiltration. It also lacks necessary maintenance which makes it unable to be filled and then dry immediately

after the autumn season. Some has stopped as a result of lack of water from the irrigation canals.

- The non fenced Hafirs used by animals susceptible to pollution together with the spread of Frendid worm in the south of the State.
- Design of low productivity wells in soft sands without concrete cover or without isolating the salty layers which make it susceptible to repetitive breakdown, high exploitation cost and it is susceptible to salinity.
- Use of expensive technologies to pump water like reciprocating pumps of low productivity which multiply water production cost. Water tanks and metallic pipe lines are susceptible to damage caused by erosion
- The non unified pattern or standardization of water equipments and machines which hinders the maintenance process and raise its cost.
- Lack of protective maintenance system, lack of spare parts, weakness of human cadre and the weakness of financial resources.
- The high cost of the White Nile water treatment beside the small number of customers which multiplies the operational cost with a low return.
- The great loss in the distribution network with the low rate of water fees collection from the returns of water sale especially for government utilities and that's for many years without stopping the supply.

- Weakness of distribution network and the low water pressure in peripheral areas which made people install water pumps or use mobile water and from contaminated sources.
- Repetitive breaking down of water supplies in urban centers as a result of electricity acts.
- Lack of treatment materials, the deterioration of pumps and distribution networks.
- Low water fees and it's non-confirming with the water markets.
- Lack of modernization budgets

4.9.1.5.3 Social and Environmental:

- Increase of poverty rate and deterioration of health awareness among citizens and their preference to the river water and the polluted (Idd) well's water.
- High cost of providing water for small groups of population which is scattered.
- Poor and ineffective participation of citizens in providing water because of unorganized and untrained societies, they totally rely upon the government only Gitaina province is an exception in this respect.
- Conflict around water sources between different ethnic and tribal groups and among the migrated and sedentary groups.
- Environmental deterioration caused by drought intervals and migration of groups towards water areas. This caused pressure upon available sources and led to their collapse.

4.9.2 Sanitation Services in the White Nile State

According to population census (1993), more than 50% of the inhabitants of the central region which comprises the White Nile State has no suitable sanitation facilities, 57% of them in rural and 31% in the urban (table 4.22).

Table (4.22): the Percentage of Population has no Sanitation Facilities in the North Sudan

The Region	*The Percentage*		
	Rural	**Urban**	**Total**
The Northern	37	14	51
The Eastern	68	34	53
Khartoum	18	15	15
The Middle	57	31	50
Kordofan	35	28	39
Darfor	35	10	32

Reference: Population Statistics 1993

The improvement of sanitation services in Sudan (UNICEF – Developmental and Environmental Services- 1999) showed that 33% only of Sudanese population enjoys suitable sanitation services whereas the rate is increasing in the urban centers to 57% (the State WES Department).

4.9.2.1 Sanitation Services in Rural White Nile State:

Traditional pit latrine is considered the main characteristic of sanitation services in the rural areas of Sudan. A hole of 1-5 meters deep is dug and covered by local materials or concrete slab, and built by bricks in the sandy areas and no pipe is used for ventilation.

This system is prevalence in Gitaina province and it covers 30% of its rural areas need which is 33.000 household latrines and it is usually owned

by the families with high rates of income, whereas the Water and Sanitation project (WES) supported the poor families in its targeted areas.

Survey results, undertaken by Plan-Sudan organization, showed that traditional pit latrines covers around 3% of rural Eddwueim province whereas the majority of people practice open defecation or near to the irrigation canals which are the main source of drinking water.

Improved and ventilated pit latrine systems (VIP) were introduced in the White Nile State by the Water and Sanitation project (WES) in 1995 when, during the period (1995-1999) 3,679 household latrines and 31 school latrines were constructed. Also 257 health committees were made and trained in the villages. Around 3,500 people benefit from sanitation services which represent 7% of rural population in the State. Most of the services are in Gitaina province. Within the rural areas, there are a small number of sanitation facilities in the markets and restaurants especially along the highway roads. Most of the traditional latrines established in schools have collapsed because of the unsuitable technology used for the soils conditions, this adversely affected the presence of students specially girls. Generally, the rate of coverage of latrines in the state estimated to be 15%.

The health situation worsens as a result of the way of keeping animals inside the houses for security reasons. Solid wastes are thrown in the streets and within house. There are no drainage system for rain waters causing water pools (Birak), especially in the clayey soils which attract flies and malaria transmitting mosquitoes which spread in the rural areas of the State. The water shortage is one of the obstacles to sanitation system and personal hygiene (the State WES Department).

4.9.2.2 Urban Sanitation Services:

There is no statistics on sanitation in the semi-urban areas in the state. But the situation is similar to the rural areas.

Sanitation facilities in urban places are represented in the following types:

- Soak-away system and sewage which is owned by able families in grade one quarters in Kosti, Rabak and Kenana towns (Table 4.23).
- Water latrines represent the economical means to get rid of human waste and it does not require much water.
- Improved and ventilated improved pit latrines (VIP) and it's used in large numbers in Kosti, Gitaina and Tendalti.

From Table (4.23) the following can be observed:

- Deterioration of sanitation services in Kosti the largest town in the State. The 1999 coverage is 36%. The rate reaches higher levels in Gitaina and Gazeira Aba towns and reaches 100% in Kennana.
- The mobile solid wastes reaches 21.4% of the wastes collected in the towns. This causes health problems especially in displaced camps and among agricultural labor.
- Liquid industrial waste for Kenana sugar factory is the greatest environmental problem in the State, the thing that requires quick solution.

Current sanitation systems cause the groundwater pollution which is near to surface especially in Gitaina town which requires improvement of its facilities to protect the groundwater from pollution.

Table (4.23): The Environmental Sanitation Services in the Urban Areas (1999)

Town	*Number of Houses*			*Solid Wastes*			*Environmental Hazards*
	Total	*Provided by Latrines*	*Percentage*	*Total Volume(Ton)*	*Transmitted Volume (Ton)*	*Percentage*	
Kosti	41,660	15,200	36%	150	40	27	Flautor, oil factories and random lodging wastes.
Tandalti	9,667	4,070	42%	25	6	24	Oil factories, near surface water and human wastes.
DWM	10,977	6,700	61%	42	12	29	Underground water pollution.
Gitaina	2,689	2,097	78%	18	8	44	Underground water pollution.
Elkawa	887	472	53%	4	0.2	5	Underground water pollution.
Gazeira Aba	3,908	3,560	91%	36	2	6	Wastes, flood water and irrigation canals.
Rabak	11,410	5,992	53%	128	18	14	Cement factory's vapors, wastes
Kennana	2,519	2,519	100	-	-	-	Industrial liquid wastes and irrigation canals.
Total	**83,717**	**40,610**	**48.5**	**403**	**86.2**	**21.4**	

- As a result of low water pressure and its repetitive intermission, people resort to store water in open barrels for days which provide good environment for mosquitoes that transmit malaria which is also spreads in towns all through the year.
- There are many ways of collecting, transporting and burning the garbage, but the methods are limited. The liquid waste of sugar factories, especially Kennana, which is thrown in the open, is the most important pollution source for urban environment in the State. There is a need to request the factories to treat these wastes before they reach the River Nile.
- The smoke rising from Rabak Cement Factory is an environmental threat to the nearby areas. The pollution of shallow groundwater caused by latrines is seen clearly in Gitaina, Edduweim and Elkawa areas and the southern parts of Kosti town.
- As a result of healthy water shortage and deterioration of environmental health and health awareness, the diseases related to and caused by water and sanitation are spread in the State towns (Table 4.24).
- It is required to mobilize communities and increase their awareness towards the hazards of environmental health deterioration and to advice for the use of suitable techniques it also requires the national and international support (the State WES Department).

Table (4.24): Diseases Related to Water and Sanitation

Disease	*Cases infected*	*Number of Mortalities*	*Percentage of Mortality*	*Remarks*
Malaria	6,871	124	1.8	Critical duration – maximum (July-October)
Diarrhea	3,640	212	5.8	Critical duration – April – July
Bilharzias	No Statistics Found			Diffusion is 60% in Agricultural areas in Asalaya and Kennana localities
Eye diseases	13,780	-	-	Diffused in the rural areas due to week personal hygiene
Typhoid & dysentery	No Statistics Found			Diffused in the rural areas that depends on surface water resources
Frendid warm	No Statistics Found			Diffused in the Southern borders of the State, Rawat locality.

* Reference : Environmental Sanitation Administration – the White Nile State (1999)

4.10 Water & Sanitation Sector Administration

In accordance with the federalism system, the ministerial decree No. 1155 of October 1992, was issued hereby the dissolution of the Rural and Urban Water Authorities, and a National Water Corporation was established as a federal body responsible for policies and planning for water services, and to set standards and import water machines and equipments at the federal level beside the training of the staff working in water sector. The Decree also ordered to establish State Water Corporations to administrate and maintain State Water facilities, and the establishment of federal governmental companies jointly with the States to provide digging and installing groundwater wells, rehabilitating Hafirs and dams and to manufacture water equipments and this should be run on commercial bases. The surface and the underground water research administration were attached to the General Administration for Water in the Ministry of Irrigation and Water Resources (the State NWC).

According to the Environment Health Law of 1975, which is modified in 1997, the environmental sanitation responsibility was delegated to the health committees which are consist of the health workers, Urban Planning Ministry's engineer and the local authorities.

4.10.1 Administrational and Organizational Structure:

The White Nile water authority, according to its law of 1996, took the authority of providing water services including the federal authorities. The State Water Authority is administered by an administrative council under the supervision of Ministry of physical planning headed by its general director. It has two administration bodies: rural and urban

Beside the State headquarter, the rural water administration has three centers in (Tendalti, Edduweim and Gitaina) headed by assistant directors and executive directors at the locality levels. This is beside four administration bodies at the state level, for: Engineering, Planning and Programming, Human Resources, Accounting and Operation and Maintenance administration. At the village level, there are: a clerk, a guard and a lubricator.

At the headquarter level, the Urban Water Administration works as three administration sources; distribution, administering and collection. There is an executive director at the province level it currently, works in seven state towns. The state also established two companies: one for digging and maintaining ground wells, the other for Hafirs and dams beside irrigation services (the State NWC).

The current Sanitation Administration is headed by a director under the auspice of the general director of the Ministry of Health and it is represented at the province level by the senior public health inspector, a public health

inspector at the locality level and a public health officer at the village level (figure 4.6).

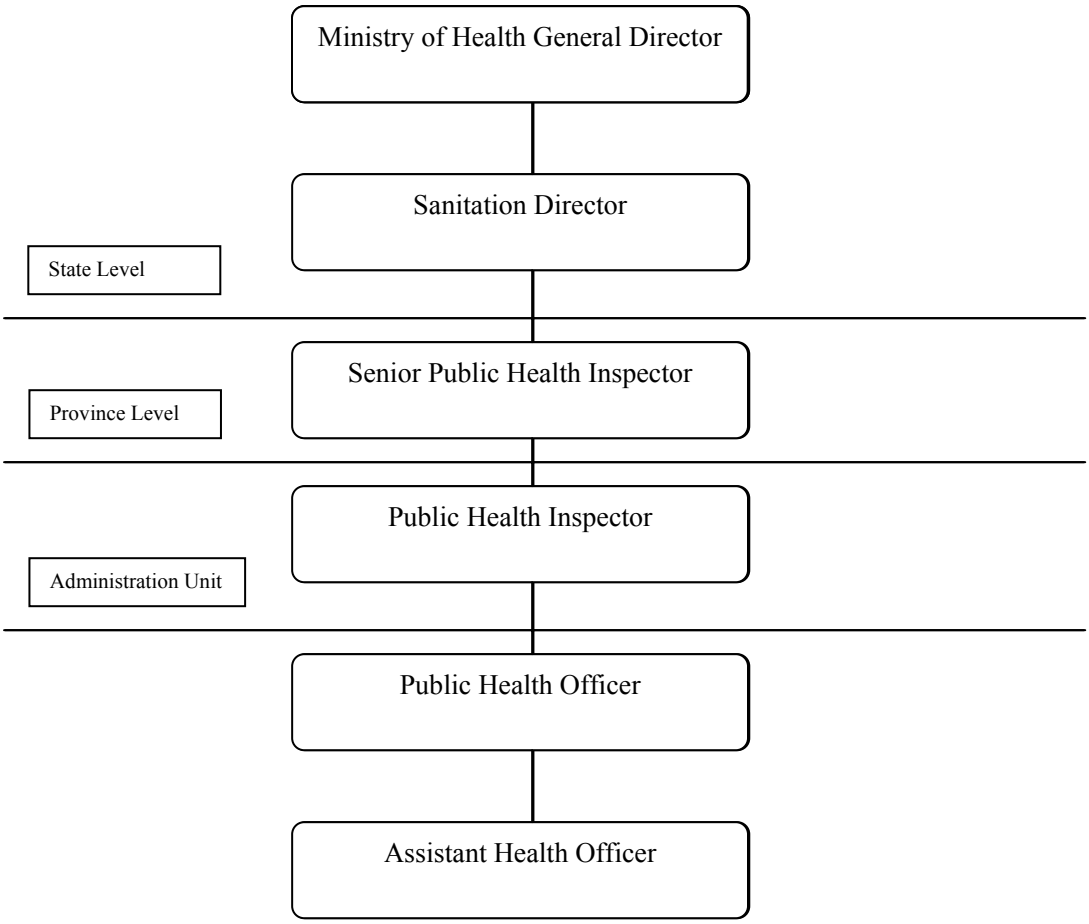

Figure (4.6): Sanitation administration structure .

4.10.2 The Administration:

The Rural Water Administration has witnessed changes along its history between the States authorities with the help of the Corporation or by the agents and between the Water Corporation till the year 1992.

The ministerial decree of the year 1994 was issued and according to, the Administration of rural water stations were put under the administration of communities represented by localities.

Currently rural water facilities are administered partially by State Water Corporation and partially by localities with a technical support of the State. Urban water is directed by the workers of the Urban Water Administration it works in seven towns, whereas, Kenana, and Assalya waters are administered by the Sugar Companies .

Rural and urban sanitation facilities are constructed by beneficiaries under the supervision of the Sanitation Administration without any coordination with the water authorities of the state. Sanitation Administration undertakes the collection and burning of garbage and the beneficiaries pay part of cost as a house fees.

As an initiative of linking between sanitation and drinking water services, the Water and Sanitation project (WES) supported the establishment of many improved latrines in the States Rural areas jointly with all the citizens.

4.10.3 Financing [6]

Historically, the government and by an international support has constructed water facilities in the rural areas without any support from the communities. Water is sold to citizens by a nominal price. The government was and still constructing water facilities in urban areas where water is sold by subsidized prices.

In the mid-nineties the government adopted the cost recovery policy, the community participation and introduced the decrease in foreign support for political reasons. Local expenditure on water services also decreased to 34%

of the approved budget of 1992, 5.6% for 1994, 8.7% for 1996, 10.4% for 1997, 8% in 1998 and less than 1% in 1999.

To ensure the sustainability of water services, the government resorted to community participation which was reflected in water fees for rural areas in the northern states which increased from 1.65 Dinars for a cubic meter in 1992/3 to 13.75 Dinars for 1993/4, 162 Dinars in 1997, 270 Dinars in 1999, and in some states it is more than 540 Dinars.

Rural and Urban water resources development in the White Nile State is financed by Central and State Government support, foreign support, (UNICEF, Plan-Sudan) and community support. Citizens bear the burdens of administration and maintenance costs. There are no statistics on development budget and development expenditure depends on the availability of money rather than depending on the program needs. Table (4.25) Show rural water fees.

Fees for animals' drinking water applied in the States rural areas as follows:

Cattle	15 Dinars/head
Donkey and horse	10 Dinars/head
Cheap and goat	5 Dinars/head
Camel	50 Dinars/head

Table (4.25): The Rural Water Fees (Dinar/ m^3)

Province	*Locality*	*Surface Water Resources*	*Underground Water Resources*		
			Goundwater wells (m^3)	*Hand Pumps (Dinar/pump/month)*	*Housee connections (Dinar/house/month)*
Kosti	*Tandalti*	137.5	412.5	-	-
	Guli	137.5	412.5	2000	500
	Rawat	137.5	-	2000	-
	Um Hani	137.5	-	-	-
	Naeim	137.5	-	2000	-
DWM	*Shabasha*	137.5	275	2000	500
	Tadamon	137.5	275	2000	500
	Wohda	137.5	412.5	2000	-
	Um Remta	137.5	412.5	2000	500
Gitaina	*Gitaina*	-	165	2000	500
	Sheikh Sidig	-	165	2000	-
	Elkawa	-	165	2000	-
Jabalain	*Gazeira Aba Asalaya*	137.5	-	-	-
	Kennana	137.5	-	-	-
	Jabalain	137.5	-	-	-

The following can be noticed from table (4.25):

- The Hafirs water fees are fixed in all localities.
- The groundwater fees reflect cost of production as well as reflecting water scarcity or availability.
- The groundwater fees are 3 to 8 times that of similar fees in the urban areas regardless of supply systems. This leads the rural poor people to resort to traditional sources or migrate to the urban areas in summer seasons.

4.10.4 Labor and Assets [6]

The number of workers in the Rural Water Administration – excluding companies' labors – 513 labors distributed as follows:

- Headquarter (Kosti)	39
- Tendalti	124
- Edduweim	78
- Gitaina	88
- Jabalain	13
- Localities	171

Total	513

Most of workers are labors; beside limited number of technical engineers. The Administrative Structure, which is approved, comprises 411 workers only. Labor surplus shows in Gitaina centers where it absorbs all water revenues from self management and the Corporation share of the stations which are administered by the communities.

Rural Water Administration requires evaluation to determine responsibilities and therefore the type and size of labor required so that its cost should not exceed 25% of the water revenues.

The Rural Water Administration owns 3 large workshops in each of Tendalti, Edduweim and Gitaina. It can be commercially utilized as a source of revenue which requires the provision of logistics and labor instead of leaving them useless as it is the case now.

The administrative and technical weaknesses are represented in the deterioration of water services in the facilities managed by the Corporation compared to the facilities managed by the communities which provide

revenue to the Corporation used in covering the deficit in workers salaries as the case of Gitaina province.

The organizational structure of the Urban Water Administration is composed of 785 person distributed as follows:

- Headquarters (Kosti)	21
- Kosti Water Station	352
- Rabak Water Station	79
- Gezira Aba Water Station	67
- Elkawa Water Station	36
- Edduweim Water Station	132
- Gitaina Water Station	65
- Tendalti Water Station	33

Most of labor are workers because the administration depends on the manual labor in the networks connections and there is a weakness in the availability of engineering equipments.

The administration owns some drilling machines, lathing and welding machines and equipment for distribution of water whereas it lacks pressure and leakage measurement equipments, water analysis, communication means and logistic. The practical training which was done during project implementation, has contributed in raising the capabilities of workers and the administration depended more upon them instead of contracted labor.

The sustainability of the urban water services requires the provision of engineering capabilities in the field of electrical, mechanical, civil engineering and laboratories, it also requires continuous training for workers to build their capacities and raise their qualification.

Sanitation administration is constituted of 98 persons who are detailed as follows:

- Senior public health inspector 1
- Public health inspector 13
- Public health officer 14
- Assistant health officer 71

The Sanitation Administration lacks logistics necessary for disposing solid wastes and transportation. This weakens its ability and hinders its cooperation with the Urban Planning Ministry engineers though there are technicians. The result was a horrible deterioration in the environmental health in the urban areas and its absence in the rural areas.

4.10.5 Water & Sanitation Sector Administration Obstacles:

The developmental and sustainability obstacles are many. The most important are:

- Lack of legal institutional relationship between sanitation and water. This led to the deterioration of the sectors services and sanitation services, especially in the factories regions with the spread of environmental diseases in the State.
- Deterioration of work environment and the weakening of the workers morale as a result of low salaries and the absence of training opportunities.
- The non-determining of responsibilities, and in a fine way at the localities, provinces and the State levels. There is a conflict on distributing rural water stations revenues.

- Poor labor quality and the excess laborer in some sub-sectors. This led to fail in utilizing the available resources. The Irish project is the best example for that.
- The use of expensive technologies and the non-unifying of the equipment and machine types which would increase operation and maintenance cost.
- Weak people participation because of lack of health awareness and technical and administration with low levels of consumption, cover and its repetitive stoppage and the non-availability of laboratories and chemical materials.
- Deterioration of most of water facilities, especially in rural areas as a result of obsolesces because it is established during thirsty combating campaigns.
- Lack of approved budgets for development works and depreciation.
- The low priority of rural water services. This resulted in increasing migration rates towards urban areas causing pressure upon their services facilities among which is water.
- Increase of poverty rates, especially among the displaced. This weakens their effective participation in developing water and sanitation services administration.

4.11 The Strategic Plan for Water and Sanitation in the White Nile State

One of the lessons of the Blue Nile Health Project researches is that the provision of healthy water alone has a weak and preliminary effect upon human health. Healthy water can be polluted during transportation, storage

and use operations. Though of the great effort exerted in sanitation and water fields and the appreciable responses of the international community, the gap between demand and supply of sanitation and drinking water is still increasing as a result of accelerating population growth, the obsolesces of most of the water facilities, specially in the rural areas and because of migration resulting from drought, desertification, civil war and tribal conflicts.

The sanitation situation is complicated in the last decade of the last century as a result of the spread of Frendid worm (in the southern states and 10 of the northern states) which has catastrophic health, economic and psychological repercussion and which is transmitted via polluted surface waters. Provision of clean drinking water beside healthy procedure are the effective means of combating the spread of this worm.

Though we are at the end of the third and last program of the Comprehensive National Strategy Project, the need for sanitation and water services is continuously increasing as a result of population increase, weak financial resources and the technical and administrative short comings of the sector's instruction.

In its effort to protect motherhood and children, and to achieve as, UNICEF endorsed the provision of healthy drinking water, adequate sanitation facilities and health awareness as a complete technical package and started to apply it in rural Sudan in the mid-seventies of the last century, using simple techniques to ensure community participation and to ensure sustainability of the services. The sanitation and water project which was supported by UNICEF and which State Water Corporations was approved has depended to apply it in the rural areas and which was accepted by most of the NGOs.

4.11.1 Comprehensive National Strategy (1992-2002) [CNS] [6]

CNS aimed at generalizing drinking water services and sanitation facilities for all citizens at the outset of the third millennium. To achieve this objective, the government approved the following strategies:

- Protection of water resources from pollution and irrational uses as a strategic objective for the long run.
- Encourage researches and studies on water resources and the best uses of water and its management systems.
- Increase community participation in planning, implementing and managing the drinking water projects depending on the cost recovery, contribution and capacity building bases.
- Endorsing simple technologies and encouraging local manufacturing of water equipments and machines and to reduce the dependence on the international market.
- Expansion in drinking water service provision to provide 18 l/c/d in the rural areas and 90 l/c/d in the urban areas by the end of the century.
- Use of water sources in the rural area as a political means to utilize the other renewable natural resources.

The program accompanying the CNS exerted special care to the rural areas with emphasis on rehabilitation of pumps, expansion in hand pumps and the improvement of the rain water harvesting systems. In the urban areas it concentrated on rehabilitation of water stations and to restore its design capacity together with the expansion in water services in the new state capitals which were upgraded into towns.

As an unprecedented step, CNS emphasized upon international directions represented in the comprehensive development of water resources, community participation, adoption of simple technology and to consider water as a commodity whose cost should be recovered.

CNS nevertheless ignored the integration between sanitation, water services and health awareness as a complete technical package. It also ignored the small communities such as the displaced, and the negative impact of the civil war on the foreign aid inflow.

During the period of the first and second programs (1992-1998) of the CNS the following where executed:

- Restructuring of drinking water sector to cope with federalism and government direction towards privatization by establishing the National Water Corporation to handle the national plans and programs, to prepare the specifications for the water equipments and their importation and to train water sector staff. Other State Water Corporations were established to be responsible for operation and maintenance, and the national water companies which work on cost effective basis with the share of the State.
- Approval of the water resources law and establishing the high council for water to undertake the responsibility of making water policies and priorities for use, for different purposes and legislations of water resources protection.
- Establishing information base at the National Water Corporation headquarter to provide information necessary for national and state planning.

- Start in producing hand pumps, water tanks and some spare parts.
- Expansion in rural water services by using hand pumps technology and to expand in urban water services especially in the national capital and some States towns, such as Kosti, Rabak, Gitaina, Edduweim, Obied, Jenaina, Gadarif, Kassala and others, and that is to provide 11 l/c/d in rural areas and 48 l/c/d in the urban areas.
- To attract the community resources and use them effectively to provide sanitation and water services and the transfer of the administration of the rural water facilities to the communities represented in the localities.
- Increase the production of drinking water in the country by 12% during the first program.

The two CNS projects were facing the following obstacles:

- The reduction of foreign support.
- The decrease of the actual expenditure on water projects from 35% in the first program to 8% in the second program and to 1% with the beginning of the third program. This led to the stoppage of most of the water facilities because of the lack of maintenance and obsolesce and the direction of the state resources towards spending on regional government.
- The damage of water facilities in war areas.
- The intensive rural-urban migration as a result of drought, war, shortage of work opportunities which caused pressure upon urban facilities including water and sanitation.

- The abundance and leaving out of working cadres and the deterioration of the workers morale as a result of low salaries and wages.

In accordance with CNS, the White Nile State managed to achieve the following:

In Rural Areas:

- Introduction of hand pumps technology whereby 200 pump were made by Water and Sanitation Project.
- Construction of 3679 home latrines and 31 school latrines.
- Rehabilitation of 14 pump station in Tandalti locality by the Irish support.
- Construction of Migainis dams, in Rawat locality with a working capacity of 100.000 m^3/day.
- Construction and rehabilitation of public taps and Hafirs in Edduweim Province by the support of Plan-Sudan organization.
- Start the rehabilitation and establishment of Hafirs and pumps by a Saudi Grant.
- Construction of slow sand filters in some villages of Assalaya localities.

In Urban Areas:

- Improvement of Kosti water services by providing water treatment station and improve the distribution network by adding 95 km as transmission lines and make 15 public water tap.

- Undertake the geophysical studies to determine water pumping fields in Tendalti town (at Um Kateerat) and design two wells, transmission line and distribution network. Also protective bridges were made to protect from floods, by the support of the State.
- Establishment of the water intake, changing the transmission line and expanding the network in Edduweim town.
- Construction of the water treatment station in Rabak with a capacity of 5000 m^3/day and start to establish the distribution network.
- Digging of 4 groundwater wells and installing electrical pumps in Gitaina town which will suffice the town needs till 2015 and start expanding the distribution network.

To all these, the following can be added:

- To fix water tariff for rural and urban areas of the state. Introduction of self management and community management experience to water and sanitation facilities.
- Structuring water sector by establishing the State Water Corporation, to work by two administrations: one for urban, the other for rural areas.
- Establish two companies in the state for groundwater and surface water services.

4.11.2 Objectives and Directives of the Strategic Plan for the State Water and Sanitation Services

- Provision of enough and clean drinking water near to the residency places.
- Provision of sanitation facilities and environmental health means.
- Raise the health awareness level among the citizens.
- Reduce indices of diseases caused by water and sanitation.
- Facilitate the provision of community services of water and sanitation.
- Save citizens effort and money spent on water provision fetched from remote places.
- Development of animal resources by provision of drinking water for animals in the pasture areas.
- Control the exploitation of natural resources in order to conserve the environment by providing water.

The plan relies upon international and national directive represented in the following:

1- Water is a scarce commodity, its source is the environment. It should be conserved and utilized in the best way to answer the human and animal needs which protect the environment and assure sustainability.

2- Generalize sanitation and water services in rural and urban areas.

3- Develop the water resources to meet the basic human and animal requirement as high priority.

4- Consider water as a commodity whose cost should recovered and catering for its economic and social returns.

5- To ensure the participation of the beneficiaries in planning, financing, implementing and administrating the water and sanitation services and to work towards privatizing the sector's services.

6- Endorse simple development with least cost to provide water and sanitation services.

4.12 Water Consumption Calculations:

4.12.1 Population Consumption Initial Condition:

- The total population in the State is about 1,227,024 based on the fourth national population census (1993) with an annual growth of 2.59%, so that the total population is about 1,492,178 in the year 1999.
- The human and animal needs for drinking water are estimated by the WHO and Federal Ministry of Health for the actual water needs in the rural population, and it reaches 20 l/c/d as a minimum requirement and increases with the increase in the rate of settlement,50-80 l/c/d in the urban regions and the needs of semi urban areas which expected development (30-60 l/c/d).
- From the data provided in chapter 4 we can also determine the available water supplies in rural, semi-urban and urban areas.
- The population number of the State is distributed by sectors. Referring to the tables (4.19), (4.20) and (4.21) The water demands and the available supply for 1999 are shown in the table (4.26).

Table (4.26): Population and Water situation 1999

Sector	***Population number***	***Water needs (m^3/day)***	***Available Supply (m^3/day)***
Rural	922,777	18,457	34,817
Semi-urban	69,530	2,086	1,098
Urban	499,876	41,970	22,657
Total	**1,492,178**	**62,513**	**58,572**

4.12.2 Animal Consumption Initial Condition:

- According to the Ministry of Animal Wealth estimations (1997), the State accommodates 6,850,480 cattle heads. The annual growth rates are, 4.5% for cows, 6.7% for sheep, 1.8% for goats and 1% for camels. These numbers are due to 1997 estimations and with these annual growths the number of the heads reached 7,458,000 in 1999.
- Kosti province accommodates 44.4% of the total State animal wealth and 56% of the State cattle, while Gitaina province accommodates only 3.4 % of the State animal wealth.
- Kosti and Rabak towns represent the most important livestock markets. The State is considered the pass way for the livestock and for the commercial road that extends from Western Sudan passes to the national capital, central Sudan and exporting ports (table 4.27).

Table (4.27): The animal numbers and the water needs for 1999

Province	*Animal number (1000) head*	*Water Needs (m^3/day)*
Kosti	3,304	58,246
DWM	2,234	27,905
Gitaina	255	4,442
Jabalain	1,665	29,255
Total	**7,458**	**119,848**

4.12.3 Population Projections

- Local statistics show that population growth rate is about 3% in Kosti, 4% in Rabak. These are the most rapidly growing towns of the State for geographic, administration and economic reasons.

A sample of calculation is carried to calculate population projection for Kosti province area in which the rate of growth is about 3% for the years 2005, 2010 and 2015 using Equation (2.1) as follows:

Rural area

- Population estimation for the P_{1999} is about 321,105
- The number of years n for 2005, 2010 and 2015 are 6, 5 and 5 respectively.
- Population projection for the year 2005 is

$$P_{2005} = P_{1999}(1+0.03)^6 = 321{,}105 * (1.03)^6 = 374349$$

Semi-urban area

- Population estimation for the P_{1999} is about 23,218
- The number of years n for 2005, 2010 and 2015 are 6, 5 and 5 respectively.
- Population projection for the year 2005 is

$$P_{2005} = P_{1999}(1+0.0259)^6 = 23218*(1.0259)^6 = 27067$$

Urban

- Population estimation for the P 1999 is about 305483
- The number of years n for 2005, 2010 and 2015 are 6, 5 and 5 respectively.
- Population projection for the year 2005 is

$$P_{2005} = P_{1999}(1+0.0259)^6 = 305486*(1.0259)^6 = 356140$$

4.12.4 Water Needs Projections:

The rate of water consumption for the study area is calculated from all of the existing water supply available in the area which is reported by the State Water Corporation for the year 1999 to be about 20 l/c/d. And for future demand it was expected that this rate will be increased to about 25, 30 and 35 l/c/d for the years 2005, 2010 and 2015 respectively

- *Daily water need (m^3) = Population * Capita daily consumption*
- *For example (Tandalti town):*

  118568 * 0.02 = 2371

*The following figures show the water consumption in year 1999:

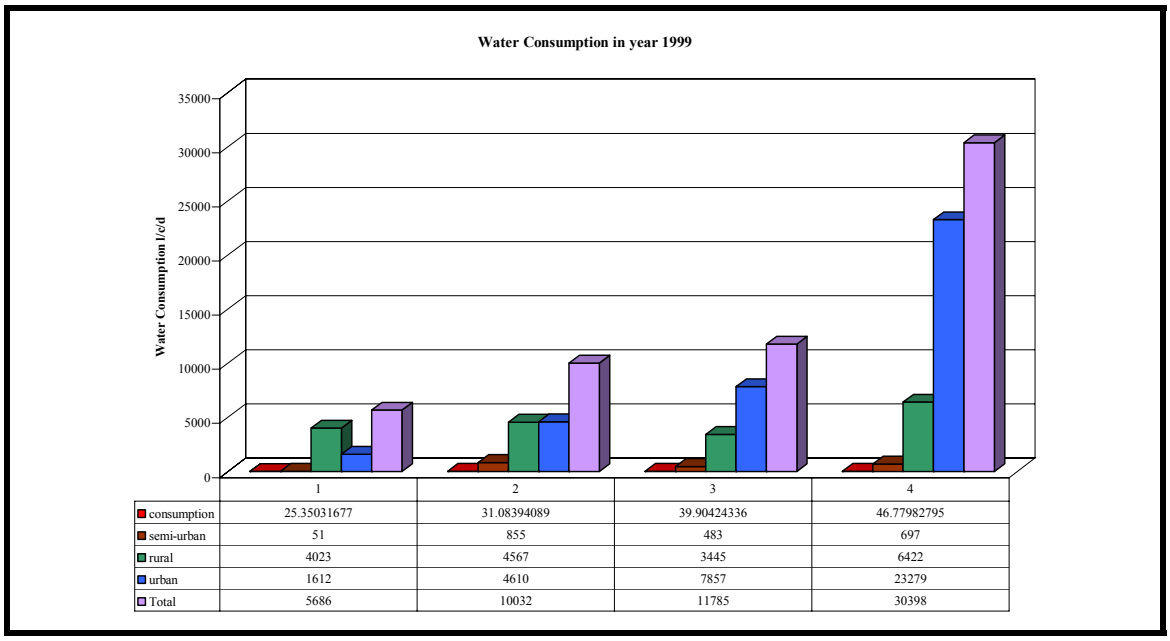

Figure (4.7): Water Consumption in 1999

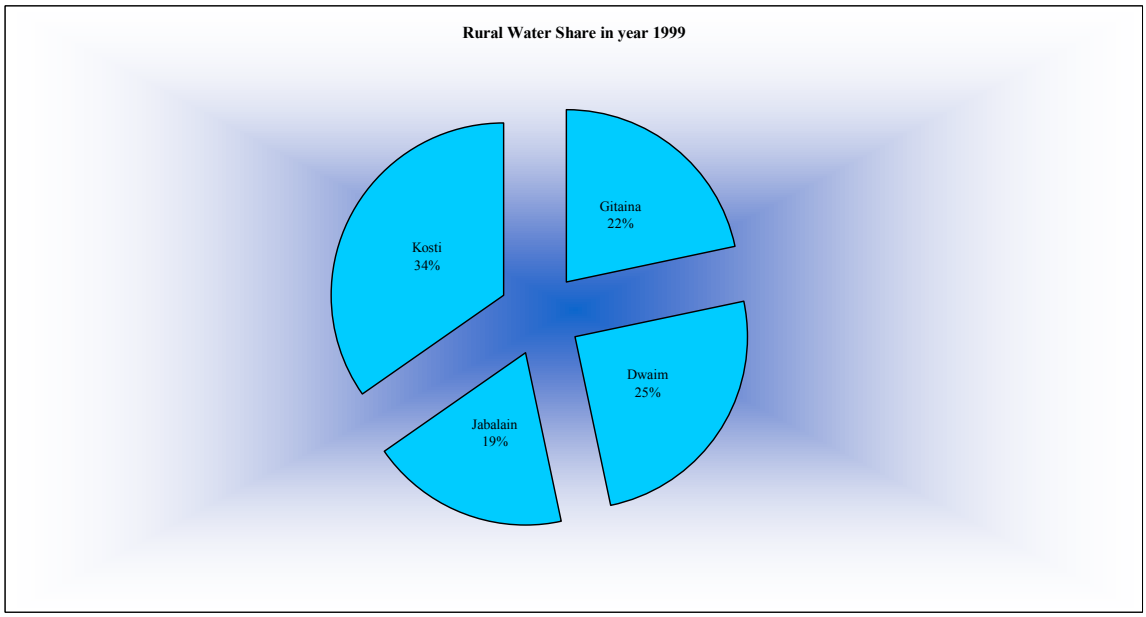

Figure (4.8): Rural Water Share in 1999

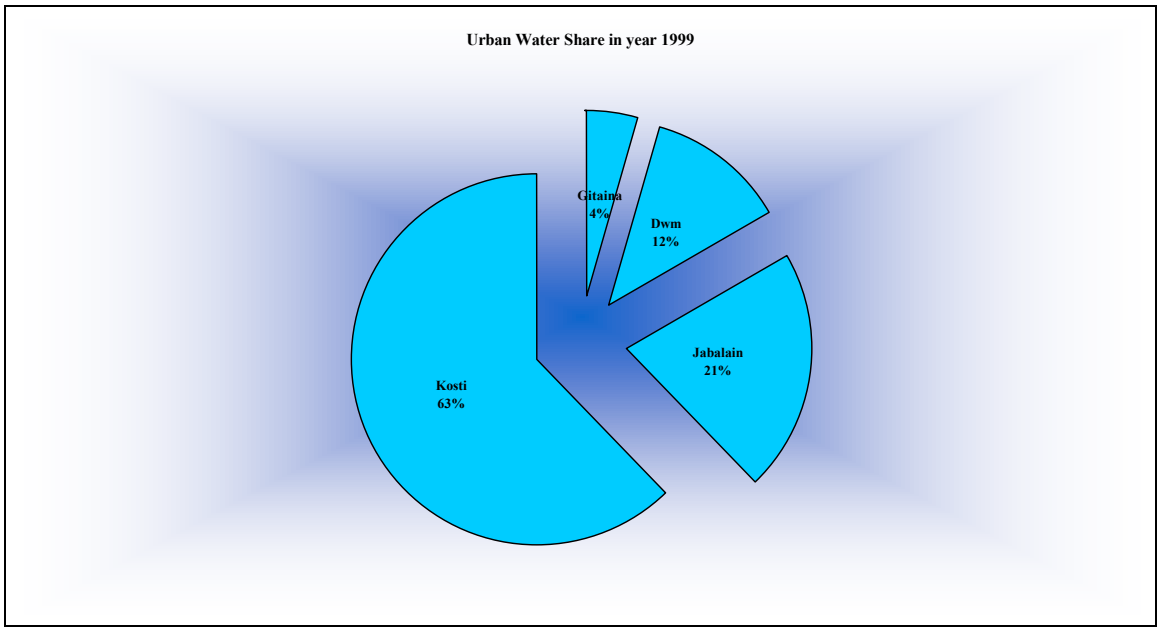

Figure (4.9): Urban Water Share in 1999

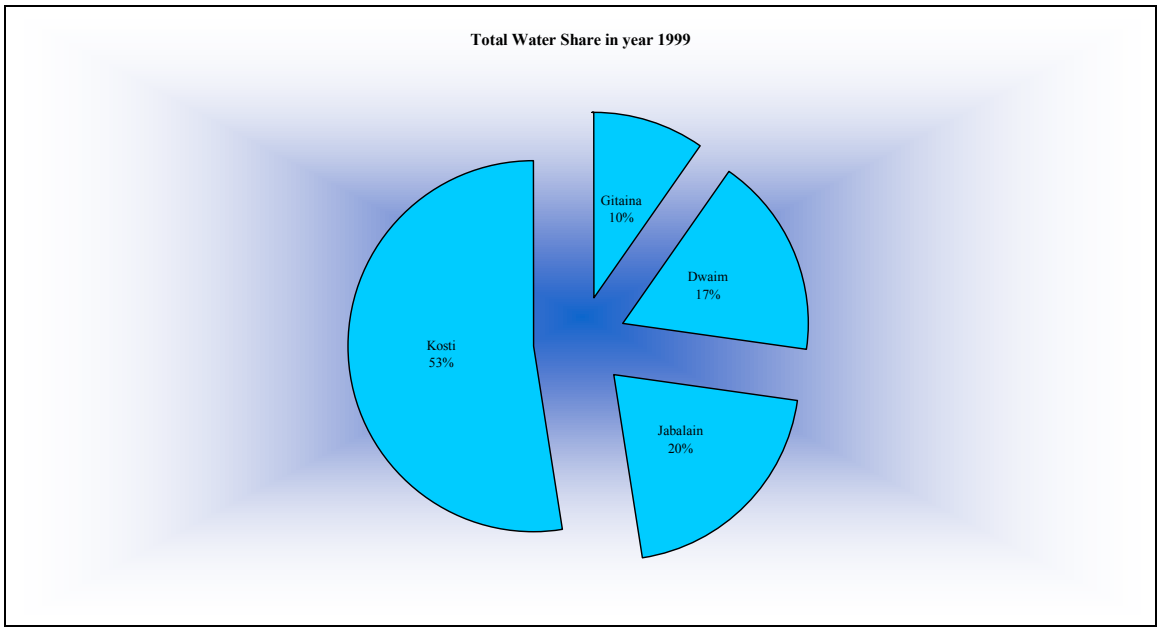

Figure (4.10): Total Water Share in 1999

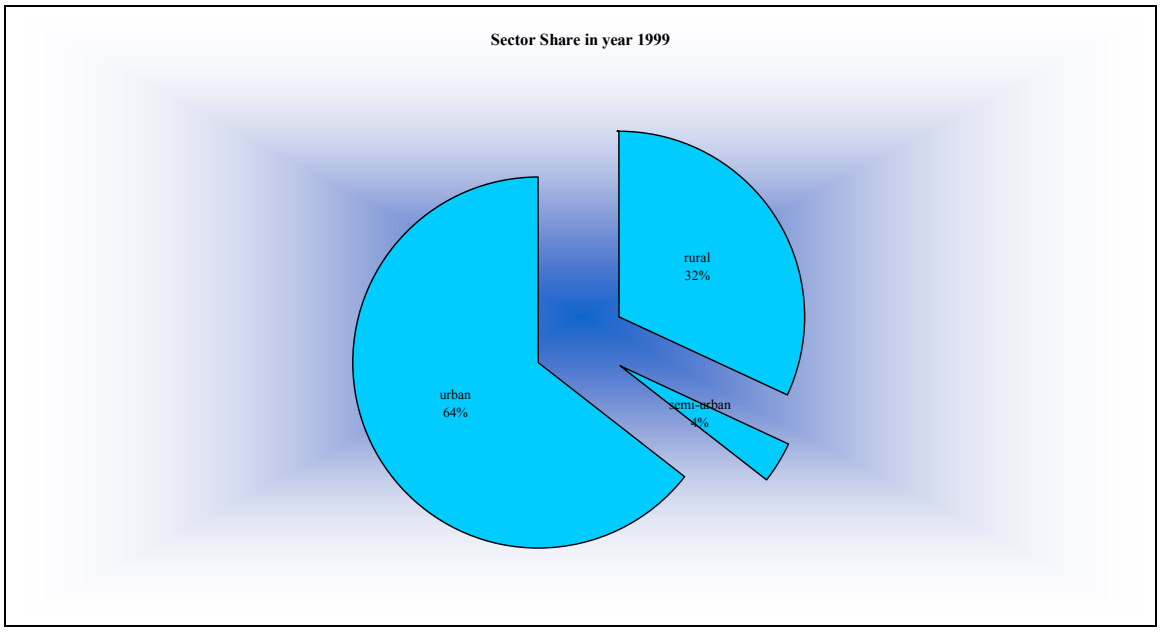

Figure (4.11): Sector Share in 1999

Chapter 5

Results and Discussion

5.1 Population

Population projections show the annual growth rate is about 2.59% in rural and semi-urban areas and (2.59% - 4%) in the urban areas in the years 1999, 2005, 2015, this shown in (table 5.1).

Table (5.1): The White Nile State population projection for 2005, 2010, 2015.

Province	*Sector*	*1999*	*2005*	*2010*	*2015*
Kost	Rural	321,105	374,349	425,401	483,420
	Semi-urban	23,218	27,067	30,759	34,956
	Urban	305,486	354,522	409,441	472,869
	Total	**649,810**	**755,938**	**865,601**	**991,272**
DWM	Rural	228,357	266,223	302,531	343,793
	Semi-urban	28,520	33,249	37,782	42,936
	Urban	65,862	76,783	87,254	99,154
	Total	**322,739**	**376,255**	**427,567**	**485,883**
Gitaina	Rural	201,106	234,453	266,428	302,764
	Semi-urban	1,684	1,963	2,231	2,535
	Urban	21,507	25,073	28,493	32,380
	Total	**224,297**	**261,489**	**297,152**	**337,679**
Jabalain	Rural	172,204	200,755	228,196	259,250
	Semi-urban	16,108	18,780	21,341	24,252
	Urban	107,020	131,577	156,475	186,276
	Total	**295,332**	**351,112**	**406,012**	**469,778**
Total		**1,492,178**	**1,744,794**	**1,996,332**	**2,284,612**

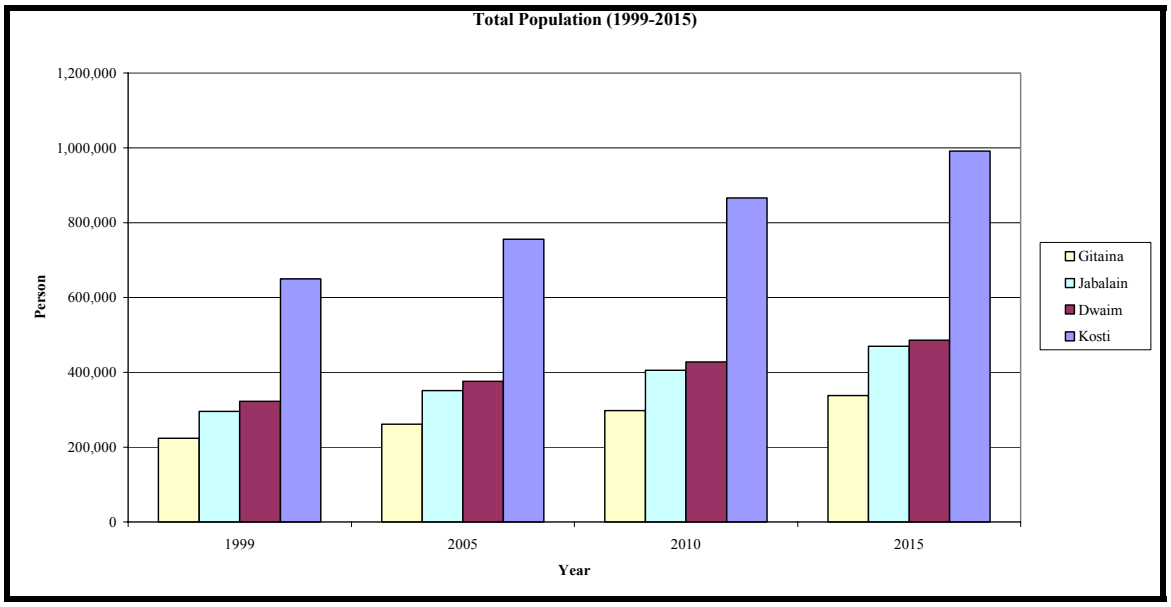

Figure (5.1): Total Population (1999-2015)

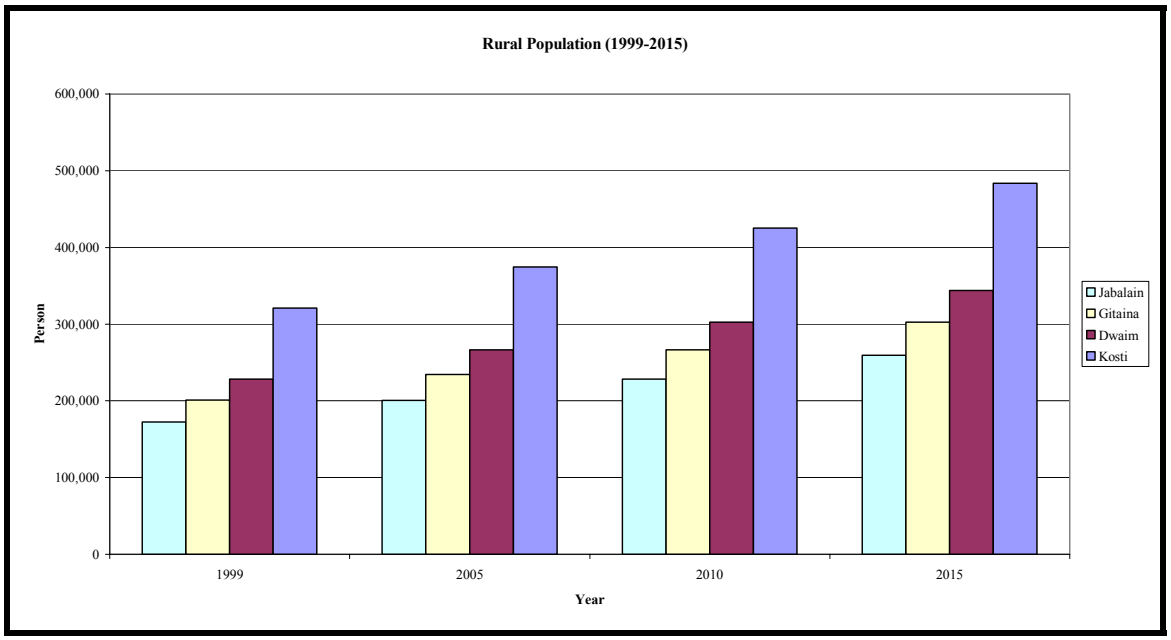

Figure (5.2): Rural Population (1999-2015)

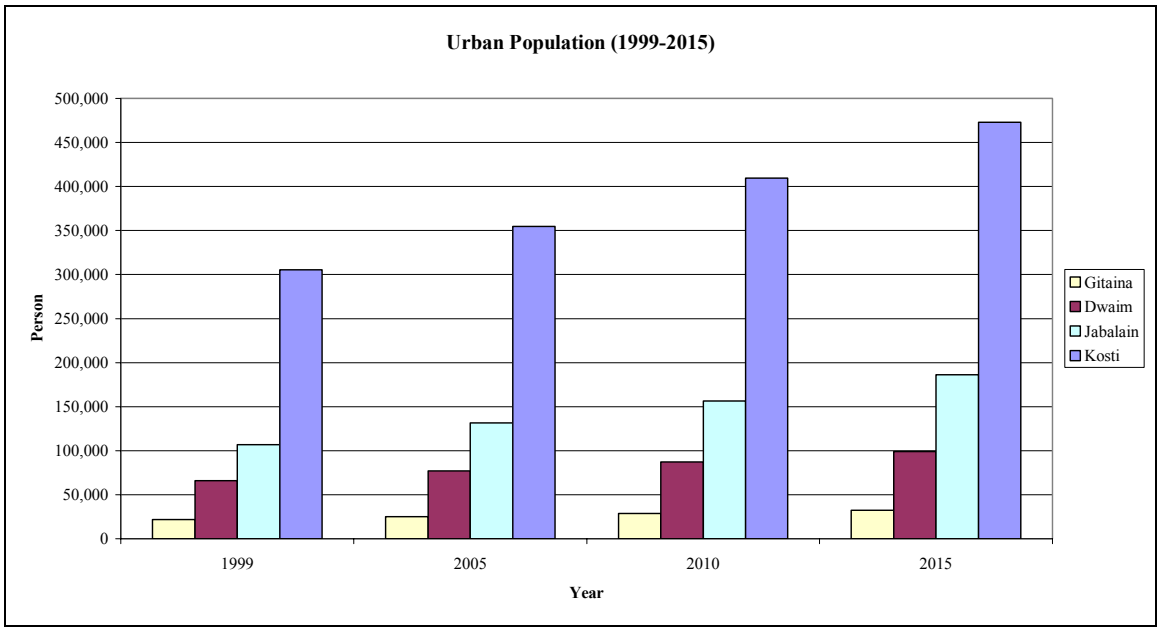

Figure (5.3): Urban Population (1999-2015)

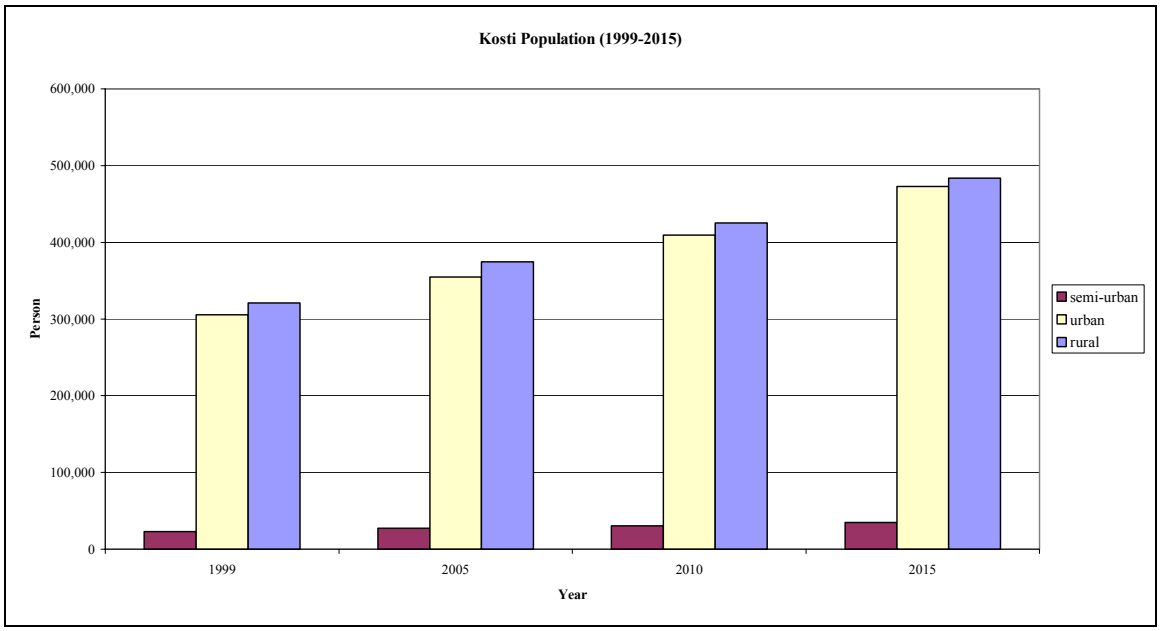

Figure (5.4): Kosti Population (1999-2015)

From the figures above:

- the total population increases 8.5% on average every five years.
- For the urban population kosti town has the highest rates of growth as Kosti, Rabak and Asalaya towns are important and economically attractive regions for the population, and are inhabited by around 60% of the urban population in the State. Excluding Tendalti and Rawat, all urban regions are located along the Nile
- Desertification and its results, which is represented in population and their incomes instability and increases the migration rates from the semi-urban areas to the urban areas (Kosti example)
- Also from kosti example its clear that population concentrated in the urban and rural areas of the province.

Urban population constitutes 38% of the State population according to 1993 census, compared to only 15% in 1955/56. This is ascribed to the increase in the rates of rural-urban migration as a result of imbalanced development and because of drought and civil war. The UN estimates the urban population in the developing countries to be 50% in the year 2050 which requires to be put in consideration when planning for services [6].

5.2 Animal Wealth:

- The annual growth rates are, 4.5% for cows, 6.7% for sheep, 1.8% for goats and 1% for camels. These numbers are due to 1997 estimations and with these annual growths the number of the heads reached 7,458,000 in 1999, and 14.8 million head in 2015 (table 5.2).

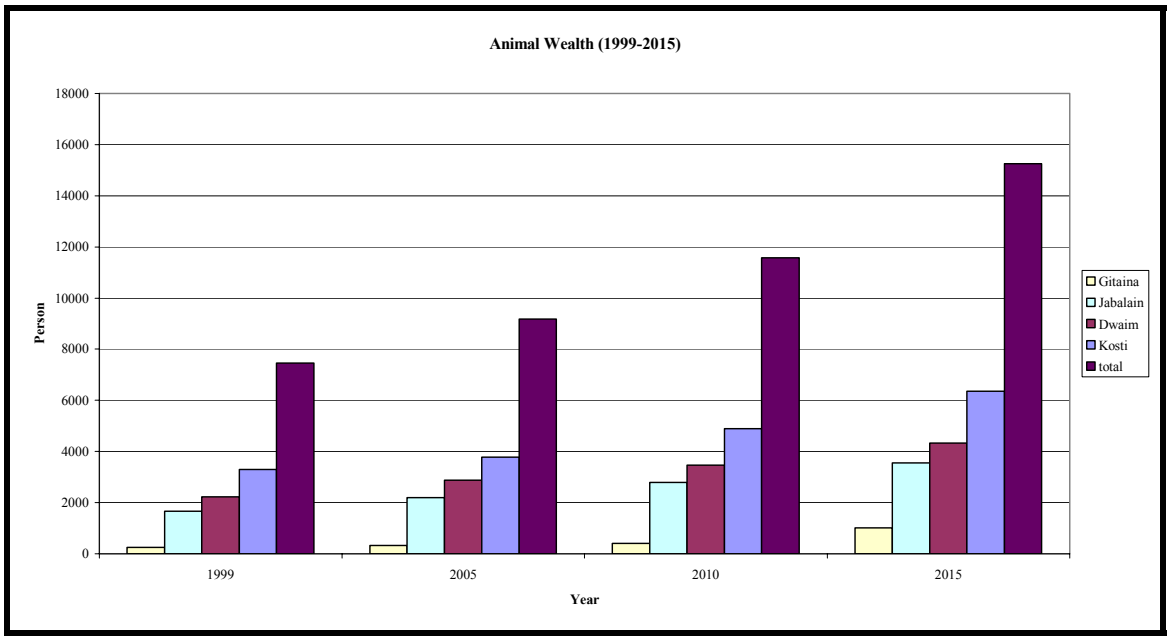

Figure (5.5): Animal Wealth (1999-2015)

From the figure above :

- Kosti and Rabak towns represent the most important livestock markets.
- Consecutive drought intervals and its repercussion of pasture deterioration and the loss of animal wealth can be seen clearly in Gitaina provimce.

Table (5.2): The State animal wealth projection for 2005, 2010, 2015 (1000 Head)

Province	1999				2005				2010				2015			
	Cows	Sheep	Goats	Camels	Cows	Sheep	Goats	Camels	Cows	Sheep	Goats	Camels	Cows	Sheep	Goats	Camels
Kosti	1,674	1,006	576	48	2,180	1,483	65	51	2,717	2,052	71	53	3,386	2,837	77	56
DWM	359	748	1,037	90	468	1,154	1,154	95	583	1,527	1,262	100	727	2,111	1,380	105
Gitaina	120	70	19	46	156	104	22	49	195	144	24	51	243	199	26	540
Jabalain	837	515	288	25	1,091	759	321	27	1,359	1,050	351	28	1,694	1,452	383	30
Total	2,990	2,339	1,920	209	3,895	3,450	1,562	222	4,854	4,773	1,708	232	6,050	6,599	1,866	245

5.3 Water Needs

The human and animal needs for drinking water are estimated according to the projected population for human and animal in the State. The tables (5.3), (5.4) and (5.5) show the needs for water in 1999 and future 2015 for the State population in the rural, urban and semi urban regions as follows:

Table (5.3): The need of water in rural areas (1999-2015)

Province	***Locality***	***Daily needs (m^3)***			
		1999	**2005**	**2010**	**2015**
		for 20 l/c/d	**for 25 l/c/d**	**30 l/c/d**	**35 l/c/d**
Kosti	*Tandalty*	2,371	3,456	4,712	6,248
	Guli	2,433	3,546	4,834	6,410
	Um Hani	253	369	503	667
	Naeim	477	695	948	1,257
	Rawat	888	1,294	1,764	2,339
	Total	**6,422**	**9,360**	**12,762**	**16,921**
DWM	*Shabasha*	1,375	2,004	2,733	3,624
	Tadamon	1,150	1,676	2,285	3,029
	Um Remta	881	1,284	1,751	2,322
	Wohda	1,161	1,691	2,306	3,058
	Total	**4,567**	**6,655**	**9,075**	**12,033**
Gitaina	*Shaikh Sidig*	602	877	1,195	1,585
	Elkawa	1,337	1,948	2,656	3,521
	Gitaina	2,084	3,037	4,141	5,490
	Total	**4,023**	**5,862**	**7,992**	**10,596**
Jabalain	*Gazeira Aba*	826	1,203	1,643	2,176
	Asalaya	623	908	1,238	1,641
	Kennana	1,184	1,725	2,352	3,119
	Jabalain	812	1,183	1,613	2,138
	Total	**3,445**	**5,019**	**6,846**	**9,074**
Total		**18,457**	**26,896**	**36,675**	**48,624**

Table (5.4): The need of water in semi urban areas (1999-2015)

Province	*Locality*	*Daily needs (m^3)*			
		1999	**2005**	**2010**	**2015**
		20 l/c/d	**25 l/c/d**	**25 l/c/d**	**25 l/c/d**
Kosti	*Guli*	242	376	533	727
	Rawat	171	266	378	516
	Naeim	53	82	116	158
	Um Hani	231	359	510	695
	Total	**697**	**1,083**	**1,537**	**2,096**
DWM	*Shabasha*	361	561	797	1,087
	Ziraiga	38	59	84	115
	Wad Nimir	300	466	662	903
	Um Jar	156	243	345	471
	Total	**855**	**1,329**	**1,888**	**2,576**
Gitaina	*Shaikh Sidig*	51	79	112	152
Jabalain	*Asalaya*	253	393	559	762
	Jabalain	230	358	508	693
	Total	**483**	**751**	**1,067**	**1,455**
Total		**2,086**	**3,242**	**4,242**	**6,279**

Table (5.5): The need of water in urban areas (1999-2015)

Province	*Town*	*1999*		*2005*		*2010*		*2015*	
		L/C/day	**m^3/day**	**L/C/day**	**m^3/day**	**L/C/day**	**m^3/day**	**L/C/day**	**m^3/day**
Kosti	*Kosti*	80	19,799	90	25,821	100	33,260	110	42,413
	Tandalty	60	3,480	70	4,733	80	6,147	90	7,859
	Total		**23,279**		**30,554**		**39,407**		**50,272**
DWM	*DWM*	70	4,610	80	6,149	90	7,853	100	9,915
Gitaina	*Elkawa*	60	322	70	438	80	569	90	728
	Gitaina	80	1,290	90	1,693	100	2,138	110	2,762
	Total		**1,612**		**2,131**		**2,707**		**3,400**
Jabalain	*Gazeira*	50	1,172	60	1,640	70	2,174	80	2,824
	Aba								
	Kennana	80	1,208	90	1,587	100	2,003	110	2,503
	Rabak	80	5,477	90	7,796	100	10,539	110	14,104
	Total	**80**	**7,857**		**11,023**		**14,716**		**19,431**
Total			**37,358**		**49,857**		**64,683**		**83,018**

Table (5.6): The total need of water for rural and urban areas (1999-2015)

Province	*Town*	*1999*	*2005*	*2010*	*2015*
Kosti	*Rural*	23,279	30,554	39,407	50,272
	Semi-urban	697	1,083	1,537	2,096
	Urban	6,422	9,360	12,762	16,921
	Total	**30,398**	**40,997**	**53,706**	**69,289**
DWM	*Rural*	4,610	6,149	7,853	9,915
	Semi-urban	855	1,329	1,888	2,576
	Urban	4,567	6,655	9,075	12,033
	Total	**10,032**	**14,133**	**18,816**	**24,524**
Gitaina	*Rural*	1,612	2,131	2,707	3,400
	Semi-urban	51	79	112	152
	Urban	4,023	5,862	7,992	10,596
	Total	**5,686**	**8,072**	**10,811**	**14,148**
Jabalain	*Rural*	7,857	11,023	14,716	19,431
	Semi-urban	483	751	1,067	1,455
	Urban	3,445	5,019	6,846	9,074
	Total	**11,785**	**16,793**	**22,629**	**29,960**
Total		**57,901**	**82,946**	**105,962**	**137,921**

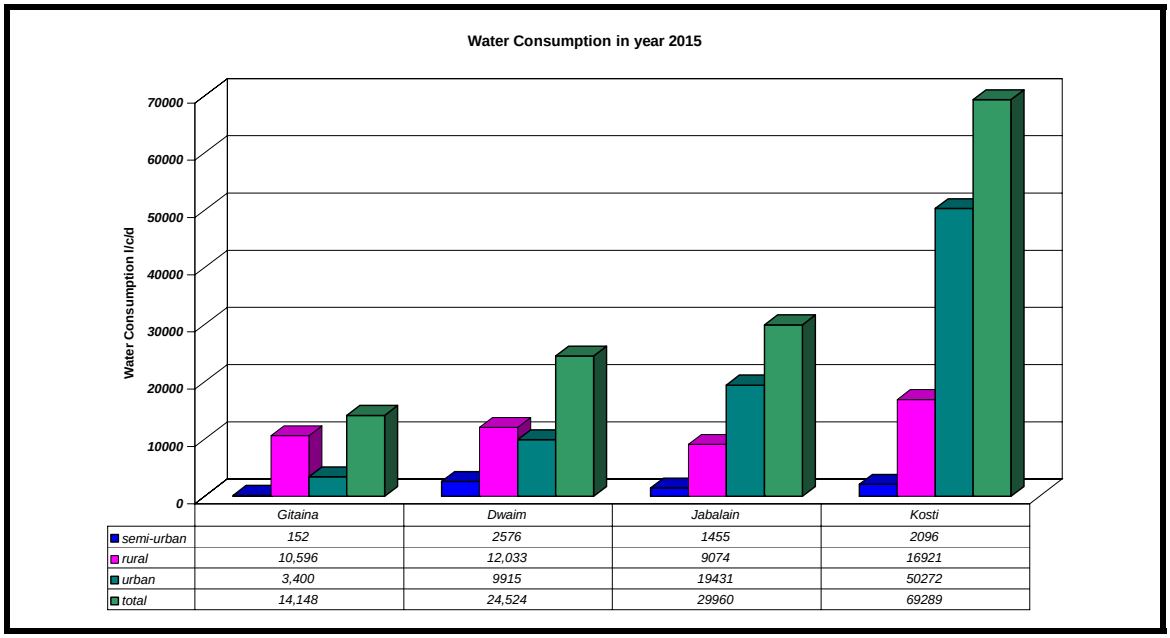

Figure (5.6): Water Consumption in 2015

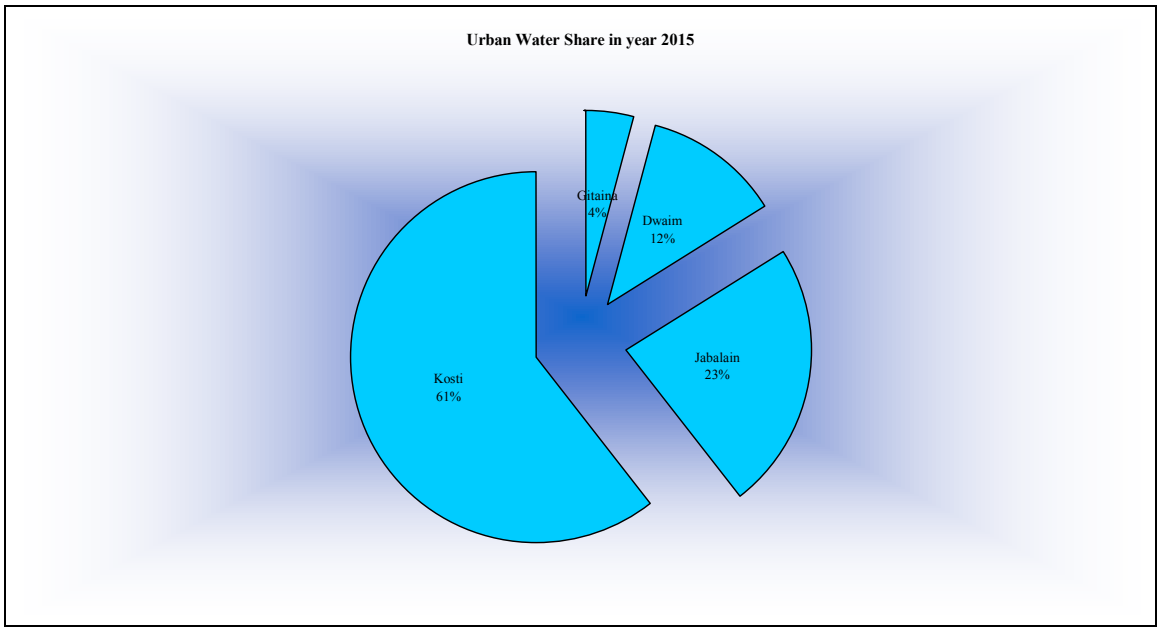

Figure (5.7): Urban Water Share in 2015

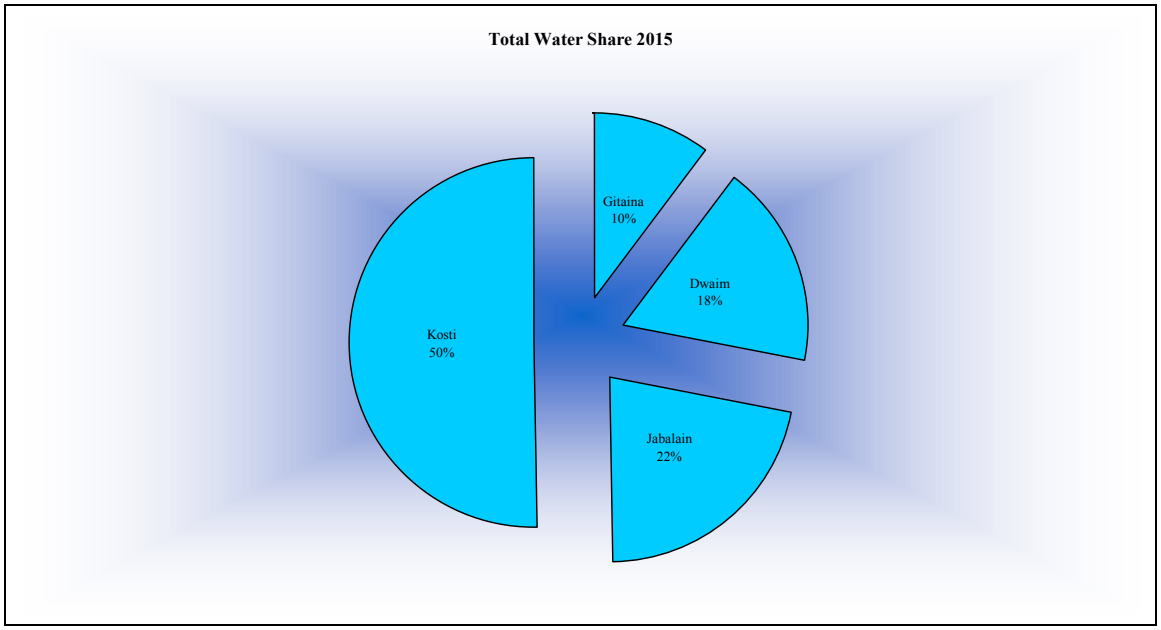

Figure (5.8): Total Water Share in 2015

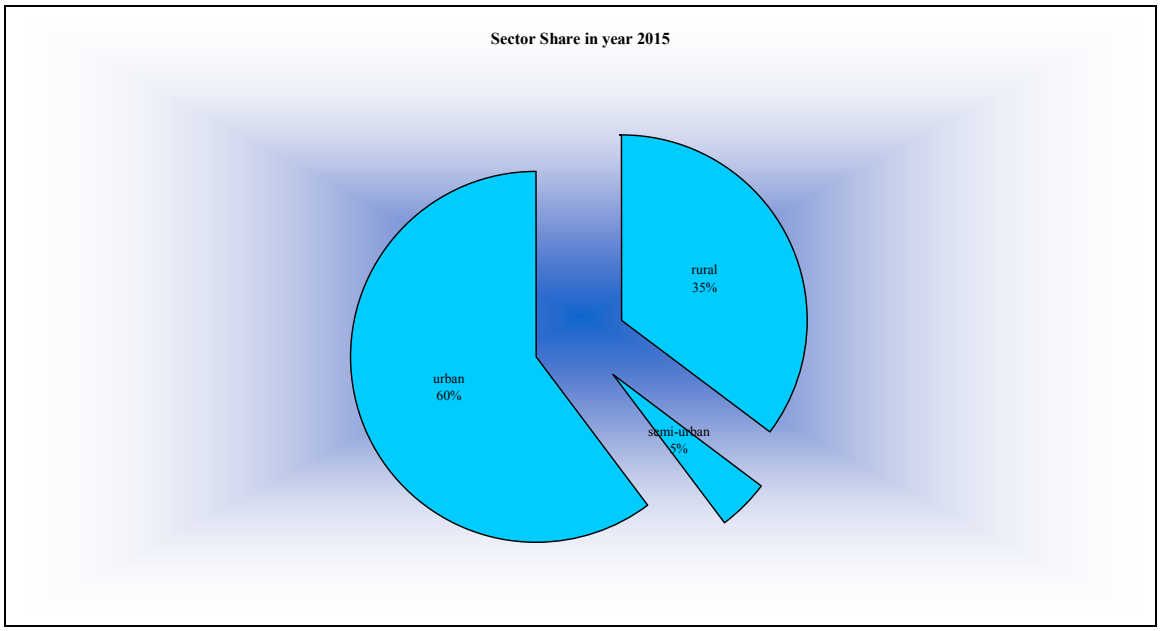

Figure (5.9): Sector Share in 2015

From the tables and the figures above the following can be deducted:

- The water consumption increases with the increase of population
- The rural requirements which is 18,500 m^3/day (1999). Kosti province requirements are estimated to be 34% of the rural needs in the State.
- Semi urban centers, which are 11, and they are represented the new localities headquarters requires 2,086 m^3/day by the year 1999 and increases to 6,279 m^3/day by the year 2015 i.e. an increase of 100% every 5 years (table 5.4).
- From the 1999 total requirements, which are 2,086 m^3/day, the share of Kosti towns is 53% and Edduweim province is 17%, Gitaina province is 10% and Jabalain is 20%. by 2015 this rates will be almost the same.
- The 1999 requirements of the urban population is estimated to be 37,358 m^3/day distributed between Kosti 63%, DWM 12%, Gitaina

4%, Jabalain 21%. by 2015 this rates will be almost the same.(table 5.5).

- From the overall need for drinking water (1999) which is 57,901 m^3/day the rural share is 32% and the urban is 64% and the semi urban is 4%. The figures change in the year 2015 into 35% for rural, 60% for urban and 5% for semi urban (table 5.6).
- Comparing these rates of consumptions with the international standards we can find that the urban population of the State had at least the minimum rate of domestic consumption (70 l/c/d), but the semi-urban and the rural population is having quantities (20-35 l/c/d) far below the international standards which is (70 to 100 l/c/d) and at least 40 l/c/d for the places where there is no water connections.

Table (5.7): The Animal need of water in m^3/day (1999-2015)

Province	***Year***			
	1999	**2005**	**2010**	**2015**
Kosti	58,246	70,592	89,791	114,462
DWM	27,905	35,420	43,665	54,345
Gitaina	4,442	5,748	7,167	8,973
Jabalain	29,255	38,399	48,321	61,060
Total	**119,848**	**150,159**	**188,944**	**238,840**

- Table (5.7) shows the animal needs for water till the year 2015. The table shows that the needs multiply every 16 years which is the rate of increase in animal wealth whereas its daily biological needs for water are constant. The total requirement for drinking water for man and animal in the State till the year 2015 is explained in (table 5.8). The

needs rise to 177,748 m^3/day in the year 1999 to 376,761 m^3/day of water in the year 2015.

Table (5.8): The State total drinking water needs for human and animal consumption (1999-2015)

Province	*Town*	*1999*	*2005*	*2010*	*2015*
Kosti	*Human need*	30,398	40,997	53,706	69,289
	Animal need	58,246	70,592	89,791	114,462
	Total	**88,644**	**111,589**	**143,497**	**183,751**
DWM	*Human need*	10,032	14,133	18,816	24,524
	Animal need	27,905	35,420	43,665	54,345
	Total	**37,937**	**49,553**	**62,481**	**78,869**
Gitaina	*Human need*	5,686	8,072	10,811	14,148
	Animal need	4,442	5,748	7,167	8,973
	Total	**10,128**	**13,820**	**17,978**	**23,121**
Jabalain	*Human need*	11,785	16,793	22,629	29,960
	Animal need	29,255	38,399	48,321	61,060
	Total	**41,040**	**55,192**	**70,950**	**91,020**
Total		**177,749**	**230,154**	**294,906**	**376,761**

5.4 Sanitation Needs:

The size of the required sanitation facilities can be estimated in the light of population statistics projections and aslo the family size which is 6.15, 6.1 and 6 persons in the rural, semi-urban and urban areas respectively .Tables No. (5.9), (5.10) and (5.11) show the future needs for house sanitation services in rural, semi-urban and urban areas of the State.

Tables below show that:

the required house sanitation facilities in 1999 is 151 thousand in the rural and 11,400 in the semi-urban and 8,400 in the urban areas. This is in additional to the sanitation facilities in government units and social

institutions which can be estimated to be 10% in the urban, 5% in the semi-urban and 1% in the rural areas from the housing units, the figures rise to 226 thousand, 17 thousand and 132 thousand in the rural, semi-urban and urban respectively for the year 2015.

Table (5.9): The need of home latrines in rural areas

Province	***# Of home latrines needed***			
	1999	**2005**	**2010**	**2015**
Kosti	52,000	61,000	69,000	79,000
DWM	37,000	43,000	49,000	56,000
Gitaina	33,000	38,000	43,000	49,000
Jabalain	29,000	33,000	37,000	42,000
Total	151,000	175,000	198,000	226,000

Table (5.10): The need of home latrines in semi urban areas

Province	***Locality***	***1999***	***2005***	***2010***	***2015***
Kosti	***Guli***	1,320	1,540	1,750	1,990
	Rawat	950	1,100	1,240	1,400
	Naeim	290	340	380	430
	Um Hani	1,260	1,470	1,670	1,900
	Total	**3,800**	**4,450**	**5,040**	**5,720**
DWM	***Shabasha***	1,970	2,300	2,610	2,970
	Ziraiga	210	240	280	310
	Wad Nimir	1,640	1,900	2,170	2,470
	Um Jar	850	1,000	1,130	1,290
	Total	**4,660**	**5,440**	**6,190**	**7,040**
Gitaina	***Shaikh Sidig***	280	320	370	410
Jabalain	***Asalaya***	1,380	1,610	1,830	2,080
	Jabalain	1,260	1,470	1,670	1,850
	Total	**2,640**	**3,080**	**3,500**	**3,970**
Total		**11,390**	**13,290**	**15,100**	**17,140**

Table (5.11): The need of home latrines in urban areas

Province	*Town*	*1999*	*2005*	*2010*	*2015*
Kosti	*Kosti*	41,660	47,820	55,430	64,260
	Tandalty	9,670	11,270	12,810	14,550
	Total	**51,330**	**59,090**	**68,240**	**78,810**
DWM	*DWM*	10,980	12,810	14,540	16,530
Gitaina	*Gitaina*	2,690	3,140	3,560	4,050
	Elkawa	890	1,040	1,190	1,350
	Total	**3,580**	**4,180**	**4,750**	**5,400**
Jabalain	*Gazeira Aba*	3,910	4,560	5,180	5,880
	Rabak	11,410	14,440	17,570	21,370
	Kennana	2,520	2,940	3,340	3,790
	Total	**17,840**	**21,940**	**26,090**	**31,040**
Total		**83,730**	**98,020**	**113,620**	**131,780**

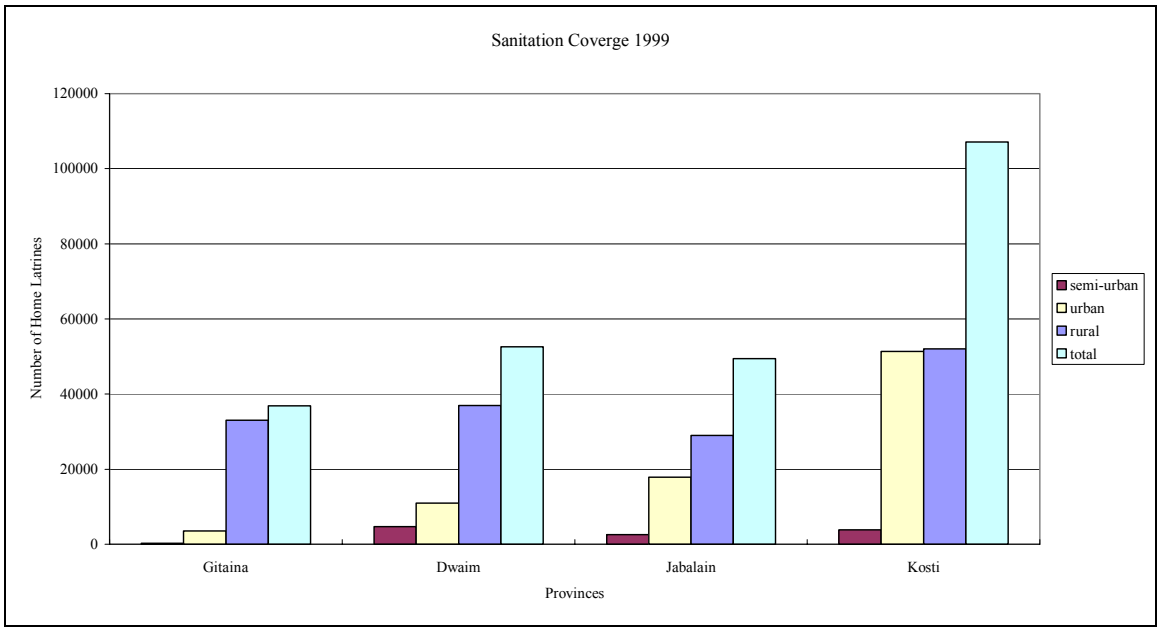

Figure (5.10): Sanitation Coverage in 1999

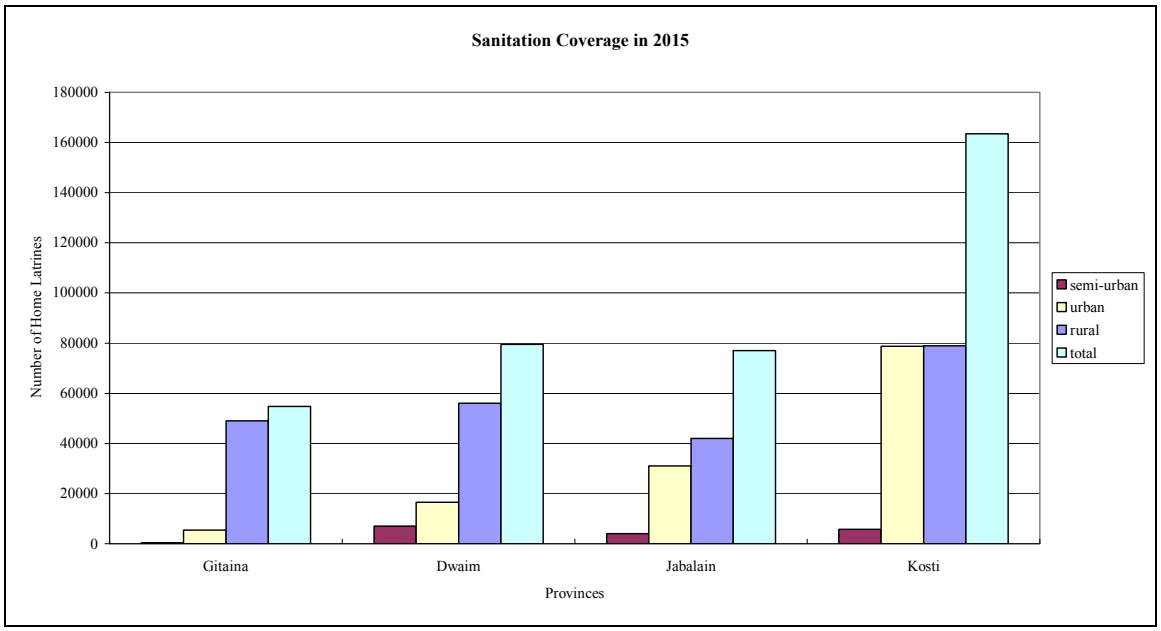

Figure (5.11): Sanitation Coverage in 2015

5.5 Water Analysis Results:

The White Nile state in central Sudan is currently facing severe problems in water supply both in quantity and quality. Towns and villages along the bank of White Nile have no adequate or lacking water treatment plants. Groundwater is extracted from shallow and deep aquifers that are meager in quantity and quality. Rainwater is harvested by digging shallow ponds (Hafirs) is not properly treated and is misused due to share use between human and animal.

The main objective of this assignment is to conduct water quality analysis necessary to investigate the suitability of a particular water source for human consumption.

Tests of water samples collected from water facilities indicated in Tables (3.2), (3.3) and (3.4) were carried out for 19 water quality parameters depicted in table (3.5). Results of tests are summarized below:

Table (5.12): Summary – Water Quality for Facilities in Kosti Province

Location / *Parameter*	*El Kawa*	*Abu Freiwah Borehole*	*Um Hani Canal*	*Gadid Idd*	*Sharga Idd*	*El Hissay Hand-pump*	*Tandalti Borehole*	*Remarks*
Turbidity	0.96	1.6	54	403	191	1.32	1.6	High Turbidity in Idd Water
S.S. mg/l	50	132	92	600	306	70	68	High S.S. in Idd Water
T.D.S mg/l	135	-	85	122	-	171	83	
pH	6.0	7	75	7.0	7.0	6.5	7.0	Normal
Total Hardness	100	260	100	340	60	180	300	Hard Water
Ca^{+2} mg/l	60	180	100	260	60	140	200	Normal Except two Locations
Mg^{+2}	40	80	00	80	00	40	100	
F-	1.3	1.3	1.6	1.6	0.8	1.3	1.6	
Cl^{-}	80	320	48	80	64	144	1280	Brackish Water in Tendalti B.H
NO_3^{-}	5	6	10	12	8	10	9	
SO_4^{-2}	9.5	5.89	17.6	3.7	6.3	3.7	3.8	
Iron (Fe^{+})	0.023	-	-	-	-	-	0.03	
Lead (Pb)	0.039	-	-	-	-	-	0.042	
Cadmium (Cd)	0.001	-	-	-	-	-	0.001	
Zinc (Zn)	0.00	-	-	-	-	-	0.00	
Cooper (Cu)	0.00	-	-	-	-	-	0.00	
Manganese (Mn)	0.00	-	-	-	-	-	0.00	
Total Coliform	-	-	-	-	-	-	-	
Fecal Coliform	-	-	-	-	-	-	-	

Table (5.13) : Summary – Water Quality for Facilities in Edduweim Province

Location / *Parameter*	*Elalaga Borehole*	*Shabasha Borehole*	*White Nile River*	*Ab Gimri Hafir*	*ElMakefi Hand-pump*	*Remarks*
Turbidity	1.7	1.3	106	12.3	1.8	
S.S. mg/l	132	40	28	138	264	
T.D.S mg/l	72	93	75	225	125	
pH	7.5	6.5	6.0	6.5	7.5	
Total Hardness	60	60	60	14.0	100	1- Turbidity is very high (River Water)
Ca^{+2} mg/l	60	60	60	100	100	
Mg^{+2}	00	00	00	40	00	
F-	1.6	1.5	1.4	1.6	1.5	2- Suspended solid is high for hand-pumps and White Nile River.
Cl^{-}	288	80	48	80	640	
NO_3^{-}	9	10	10	7	8	
SO_4^{-2}	5.6	3.65	3.82	5.19	5.15	
Iron (Fe^{+})	-	0.012	-	-	-	
Lead (Pb)	-	0.021	-	-	-	3- Hardness is Moderately Hard
Cadmium (Cd)	-	0.0015	-	-	-	
Zinc (Zn)	-	0.00	-	-	-	
Cooper (Cu)	-	0.00	-	-	-	4- Chloride is high for water from H.Pumps
Manganese (Mn)	-	0.001	-	-	-	
Total Coliform	-	2	-	0	0	
Fecal Coliform	-	0	-	0	0	

Table (5.14): Summary – Water Quality for Facilities in Gitaina and Jabalain Provinces

Location / *Parameter*	*El Gitaina Borehole*	*El Beton Haffirs*	*El Shorak Haffir*	*Remarks*
Turbidity	1.87	577	219	
S.S. mg/l	52	250	250	1- Turbidity and S.S. are very high in haffirs water.
T.D.S mg/l	87	-	70	
pH	7.5	6.5	7.0	
Total Hardness	100	100	60	2- Nitrates concentration is higher than WHO Guideline
Ca^{+2} mg/l	100	100	60	
Mg^{+2}	0.0	0.0	0.0	
F-	1.6	1.5	1.5	3- (Surface water from two haffirs):
Cl^{-}	144	64	64	- El Beton
NO_3^{-}	10	15	25	- El Shorak
SO_4^{-2}	3.6	11.7	8.6	- [NO_3^{-}]
Total Coliform	0	-	-	
Fecal Coliform	0	-	-	

5.6 Discussion of Water Analysis Results

From tables (5.12), (5.13), (5.14) of water quality results shown above, the following parameters have concentrations above WHO Guidelines:

a- Turbidity and suspended solids

b- Total Hardness

c- Chloride

d- Nitrate

As observed from the results high turbidity and suspended solids are characterizing surface water from White Nile River or Haffirs. Water from

deep boreholes or from hand pumps are characterized by high concentrations of total hardness as $CaCo_3$ and chloride contents. It is unusual to find high concentration of nitrate in surface water. Nitrate concentration higher than 10 mg/l was found in surface water (Haffirs) at El Beton and El Shorak in Jabalain province.

Chapter 6

Conclusions and Recommendations

6.1 Conclusions:

The study came up with some conclusions:

1. The State is generally characterized by the deterioration of it renewable natural resources base. Desertification, floods and industrial wastes are the most challenging environmental hazards.
2. The State is located in the dry region, the high fluctuation of the rain water rates, the short period of the rainy season, the short drought intervals, the high evaporation rates and the lack of water harvesting projects made the rain water an expensive commodity.
3. The groundwater is only found in good qualities in the Northern part of the State, its availability at the depth of more than 50 meters and the accumulation of the soft sands are considers the main obstacles to its utilization but, its quality and quantity is deteriorated in the middle and the Southern State and mostly contains high salty water (>300 unit/million) with the increase of the concentration of Sulphate and Chloride which makes it unsuitable for human consumption.
4. The main water sources are the shallow wells, Idd wells, hand pumps, Hafirs, dams and the improved sources which include treatment stations for the White Nile water, slow sand filters at the irrigated canals but, the absence of maintenance lead to the stoppage of most of these sources or just provide non processed raw water.

5. Shortage of drinking water and the deterioration of soil are considered the main obstacles for the mechanized agriculture sector development in the State.
6. The sanitation main problems are the scarcity of information and statistics, the sanitations activities are undertaken by individuals, there is no institution that supervises it, and the low ranking of the sanitation sector by the government and the societies.
7. The unplanned extensions areas and refugees camps in Kosti, Rabak, Asalaya and Kenana towns are the most areas which have an environmental sanitation problems and the spread of epidemic diseases.
8. The lack of legal institutional relationship between sanitation and water, deterioration of water environment, the low salaries of the workers, the non determining of responsibilities, the poor labor quality, the use of expensive technologies and the lack of approved budgets for development works are the main water and sanitation sector administration obstacles.

6.2 Recommendations:

To help in achieving the objectives and the directives of the CNS above it requires the adoption of the following policies by the State:

1- Strengthen and legalization the integration between water and sanitation services by restructuring the sector:

2- Encourage the private sector to invest in the field of water in order to gradually privatizing the sector's services.

3- Enhance the role of rural communities in planning, financing, implementing and managing water facilities in the rural areas bearing in mind organizing and training the communities.

4- Collect scattered villages to facilitate provisions of water and sanitation services.

5- Adopt the clean environment policy and prevent pollution and the irrational misuse.

6- Build a power-full information base in the field of sanitation at the locality, province and State levels as a base for planning.

Some other activities should be done to improve the water and sanitation services in the State and these activities can be divided by areas:

a) *<u>The Rural Areas:</u>*

1- To undertake hydro-geological studies to determine the groundwater sources at all levels (localities, provinces, States) with the aim of improving rural water supplies.

2- Cover the water requirements to meet the human and animals needs and that's will be through:

- Maintenance and rehabilitation of existing water hafirs and adding slow sand filters to improve the quality of drinking water for human.
- Protection of the surface waters (like Halba and Wad Gabor) from desert encroaelment and pollution.
- improving the technology of rainwater harvesting and to build dams and hafirs (of large capacities) to provide water all year round.

- Improve the efficiency of the existing groundwater wells and that is by cleaning them and replacing the reciprocating pumps which are of low production and expensive by turbine/electrical submersible pumps when it is possible.
- Add more groundwater wells which are of high productivity in the suitable places as an alternatives to the groups of wells of low productivity.
- Utilizing the shallow aquifers and protect their sources from pollution by:
    1- Increase the digging of deep wells and construction of hand pumps as alternatives to the traditional wells (Idds) to provide clean healthy drinking water and to conserve the human effort and money.
    2- Improve the production and the quality of the surface water wells by improving water pumping techniques.
    3- The experience of desalination of the salty groundwater wells by using filtration technique and by mobile units and by utilizing the existing groundwater wells in Kosti and Edduweim Provinces.
    4- Provision of clean water at the rate of 35 liters per capita/day by the year 2015.
    5- Reconsider the water tariff to cope with operation and maintenance costs and to achieve a profit margin to meet the improvements and sanitation services support.
    6- Adopt and encourage the improved latrines techniques in the houses which is suitable for the geological conditions, availability of water utilizing of local materials and to

consider the finance ability of the communities and their acceptance.

7- Adoption of ventilated improved pit latrines (VIP) in schools and other services and support their activities financially and technically as community awareness centers.

8- Mobilize and train communities to undertake their role in managing water facilitates and by intensifying health awareness about the affects and the dangers of environment health deterioration and water and sanitation diseases.

b) <u>Urban Areas:</u>

- Expand the existing sources to provide sufficient water according to the population needs.
- Qualifying and expanding existing distribution networks and provide house connections for 85% of the population, and public water taps for 15% of the population and provide 80-110 liters per person per day by the year 2015.
- Improve the quality of available water by raising the efficiency of treatment and to give the suitable sterilizing doses according to laboratory results.
- Support the water laboratory in Kosti as a State laboratory and provide the treatment and sterilizing materials.
- Improve water services management by:

- Provision of qualified and trained cadres, improve work environment, providing a rewording service conditions for workers and get rid of surplus labor.
- Citizens participation in planning, financing and managing the water facilities.
- Reduce water loss in the distribution network as a result of the leakage or illegal connections with rationalizing the water use.
- Establish a unit for monitoring, follow up and evaluation to do the necessary curative procedures.
- Reconsider the water tariff, regularly to cope with the operation, maintenance, and managing costs and to achieve profit margin to meet the improvement of services.
- Ensure equality in distributing water cost among citizen according to different residential levels.
- Raise the quality of collection and urge the government institutions to pay water bills and to give them a gestation period to pay the accumulated arrears.
- Protect the vulnerable areas from the danger of floods and rain water by making bridge, and suitable sewerage systems.
- Support environmental health services and its polices and urge factories to treat their wastes before disposing to ensure environment safety.
- Popularize and generalize sanitation facilities in the rural areas by the year 2015.

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Appendix

Table (1): Distribution of water projects for 2003, Northern Sudan:

State	*Wells*		*Dams*		*Hafirs*		*Filter plants*		*Total cost*
	No.	*Cost "SD000"*	*No.*	*Cost "SD000"*	*No.*	*Cost "SD000"*	*No.*	*Cost "SD000"*	
N. Darfur	25	306250	10	593820	6	153914	5	113183	1167167
S. Darfur	25	258500	2	143433	7	175000	2	45273	622206
W. Darfur	25	119825	3	190606	7	188380	-	-	498811
N. Kordofan	10	50420	10	519265	10	256524	-	-	826219
S. Kordofan	30	299100	3	226620	11	309323	-	-	835043
W. Kordofan	25	196051	5	296910	9	230872	-	-	723833
River Nile	20	103800	-	-	6	130517	21	381803	616120
Red Sea	5	24458	5	307873	5	116570	-	-	448901
Gezira	22	86589	-	-	10	222905	4	52714	462208
Gedarf	10	65700	2	97759	9	213181	1	135137	541777
White Nile	22	142120	-	-	8	187469	6	211506	541095
Blue Nile	5	22575	3	177568	5	102316	3	73801	376260
Kassala	6	29350	2	107709	5	129753	9*	235643	502455
Northern	10	30510	-	-	-	-	11	308972	339482
Sinnar	10	31900	-	-	6	122779	-	-	154679
Khartoum	11	40590	-	-	5	101364	-	-	141954
Total	261	1937748	45	2661563	109	2640867	62	1558032	8798210

* Source: Compiled from UN Office of the resident and Humanitarian Coordinator for Sudan ،

Starbase: Sudan Transition and Recovery Database, 2003 .

Table (2): summary of the Major Water intervention for 2004**:**

Main Interventions	*Planned Items*	*Expected Output*

1- New boreholes fitted with hand pumps.	1000 pumps	Improving living conditions for 2000000 women and children
2- New water yards	150	Provision of safe drinking water for 300000 persons
3. Filters plants.	40	Provision of safe drinking water for 1600000 persons
4- Rehabilitation of water yards & hand pumps.	1500	Sustain water sources for 500000 persons.
5- Construction of Hafirs.	65	Provision of safe drinking water for 130000 persons
6- Construction of dams	17	Provision of safe drinking water for 17000 persons
4- New drill rigs and new vehicles	2 drill rigs and 22 vehicles	Improved implementation
5- support of sector database	5 consultants and 5 hardware sets.	Water source digital map

* ***Source:*** *WES program, 2003*

Table (3): Implemented Projects During 1989-98

State	***Bore wells***	***Wells***	***Hafirs***	***Rehabilitated Hafirs***	***Rehabilitated stations***	***Pumps***	***Nilotic stations***	***Dams***	***Water pipe network Km***

N. Darfur	45	67	10	-	16	800	-	5	2
S. Darfur	25	4	-	-	-	150	-	-	75
W. Darfur	22	35	-	3	-	53	-	-	25
N. Kordofan	21	24	52	-	11	3000	-	-	-
S. Kordofan	5	4	3	4	-	150	-	-	1
W. Kordofan	82	337	19	84	25	1310	-	-	3
River Nile	25	-	6	-	50	-	-	-	50
Red Sea	5	25	3	-	-	-	-	2	30
Gezira	75	-	20	5	-	20	2	-	30
Gedarf	5	6	11	3	-	50	-	3	5
White Nile	30	10	10	5	-	200	3	-	70
Blue Nile	7	20	15	6	-	500	-	-	4
Kassala	20	25	6	2	-	-	-	-	10
Northern	30	-	-	-	10	-	-	-	45
Sinnar	102	-	8	-	-	1941	-	-	5
Khartoum	75	-	2	3	-	50	-	-	100

* Source: Compiled from UN Office of the resident and Humanitarian Coordinator for Sudan ،

Starbase: Sudan Transition and Recovery Database, 2003 .

Table (4): Type water resources (%), 2000

State	*Population (000)*	*Home pipe*	*Public tap*	*Pipe in yard*	*Hand pump well*	*Protected dug well*	*Protected spring*	*Rain water collection*
N. Darfur	1326	16.0	40.0	4.0	37.0	0.3	0.7	2.0
S. Darfur	2344	13.9	31.2	9.9	26.6	6.6	10.2	1.6

W. Darfur	1653	14.0	13.6	4.9	51.8	0.8	14.3	0.6
N. Kordofan	1246	1.3	77.9	2.4	6.5	0.1	3.8	8.0
S. Kordofan	1089	N.A	N.A	N.A	N.A	N.A	N.A	N.A
W. Kordofan	1537	23.9	18.2	7.5	19.0	2.1	9.8	19.5
River Nile	872	50.4	9.9	4.4	12.8	19.1	-	3.3
Red Sea	671	23.3	24.8	17.1	32.6	1.7	-	0.5
Gezira	3330	56.8	13.1	11.2	5.1	10.5	0.2	.1
Gedarf	1334	17.0	24.0	22.0	14.0	11.0	7.0	5.0
White Nile	1439	28.7	9.5	5.2	10.1	25.8	6.4	13.3
Blue Nile	599	18.4	10.2	3.1	2.8	29.8	20.8	14.9
Kassala	1435	30.0	19.0	16.0	6.0	19.0	1.0	9.0
Northern	510	57.4	13.9	4.0	8.0	11.0	-	5.7
Sinnar	1114	37.5	26.9	11.8	0.7	6.4	7.0	9.7
Khartoum	5352	56.6	31.3	3.4	3.7	0.3	2.4	2.3

* Source: Compiled from UN Office of the resident and Humanitarian Coordinator for Sudan ،
Starbase: Sudan Transition and Recovery Database, 2003 .

Table (5): People with Access to Improved Sanitation, 2000**.**

State	***% of people***
N. Darfur	62.6
S. Darfur	63.1
W. Darfur	48.2
N. Kordofan	51.4

S. Kordofan	73.1
W. Kordofan	36.2
River Nile	83.6
Red Sea	N.A
Gezira	58.1
Gedarf	39.8
White Nile	90.0
Blue Nile	62.7
Kassala	47.1
Northern	78.6
Sinnar	54.5
Khartoum	87.0

Source: *WES program, 2003*